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EFFECT OF VARIOUS ZINC SOURCES AND RATES ON ZINC AND SOME NUTRIENTS CONTENTS OF RICE

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ABSTRACT

A pot experiment was conducted to study the effects of different application sources i.e. Zn $So_4.7H_2O$, Zn Cl_2 and Zn-EDTA and rates nemly, 1.5, 3.0, 6.0 and 12.0 mg/kg soil of Zn on grain and straw yield of rice (Giza 178), rice grain Zn content and distribution of zinc fractions and their transformation in rice soils during the growing season.

The obtained results showed that the different sources of Zn increased the yield of grain and straw as compared with the control. But, $ZnSO_4.7H_2O$ had slightly effective less than ZnEDTA and ZCl_2 sources. Also, the yield was affected by the different rates of Zn sources. Data indicated that the highest increase (85 %) of grain yield was obtained at 6 mg Zn rate, while the highest increase (130 %) of straw yield was obtained at 12 mg Zn.

The macronutrients N, P and K uptake by grain and straw and its Zn concentrations increased by the studied Zn sources additions.

The highest increases in straw Zn concentration were obtained with ZnEDTA and $ZnCl_2$ sources. But, the highest increases in grain Zn concentrations were obtained with $ZnSO_4.7H_2O$ sources. Generally, the 6 mg $Zn.kg^{-1}$ soil rate was the best treatment.

The Zn contents of soil through the growing season were chemically fractionated into: water soluble and exchangeable (Zn-CA), weakly bound to inorganic sites (Zn-ACC), organically bound (Zn-pYR), occluded as free oxide material (Zn-OX), and residual (Zn-Res) mainly in the mineral structure. These fractions constituted ranged form, 0.2 to 7.4, 2.9 to 17.5, 1.0 to 20.0, 3.9 to 18.3 and 54.2 to 85.9 % of the total soil Zn respectively which ranged from 95.5 to 333.8 $mg.kg^{-1}$.

Therefore, it could be concluded that the application of Zn EDTA source at 6 mg Zn. Kg^{-1} soil rate was sufficient to produce a high rice yield and increase grain Zn-uptake.

Keywords: Zinc sources –Zinc rate- rice – Zinc fractions in soil.

INTRODUCTION

Zinc is one of nutrient elements required for maintenance of biomembrane integrity (Marschner, 1995). Most of the Zn in soils occurs on surfaces of clays, hydrous oxides and organic matter rather than soil solution (Armour *et al.*, 1990). The deficiency of Zn can severely impair crop growth and decrease yield (Celik *et al.*, 2000). Concentration of Zn in soil solution at high soil pH become very low and the mobility or Zn ion transport to the root surface are usually become a limiting factor of soil supply to this element. Sedberry *et al.* (1980) indicate that in pH ranging between 6.5 to 8.0 the content of DTPA extractable Zn in paddy soils slightly dectins. The same trend was indicated by Forno *et al.* (1975), Moraghan and Mascagni (1991) who mentioned that Zn deficiency is usually more distinct in soils with high pH and enriched with soil organic matter content. Although the application of Zn fertilizer to the soil system is economically and has long term effects for enhancing grain yield of wheat grown in Zn deficient soils (Yilmaz *et al.* (1997), the source of Zn fertilizer is also very important for the intensity factor of soil supply. Mordvedt and Gilkes (1993) showed that Zn sulphate ($ZnSO_4$) is used extensively as a source of Zn fertilizer, because its higher solubility in water and existence in both crystalline and granular forms. Also, Mahmoud *et al.* (1982) found that application of zinc sulphate up to 20 kg/fed. markedly increased dry matter by corn plant in different soils. Moreover, Shahjahan (2000) noted that NPK with $ZnSO_4$ had a vital role in enhancing the grain yield and yield contributing characters of rice, such as height of the plant, total number of tillers per hill, weight of grain yield per plot, straw weight per plot and 100 grain weight. Meanwhile Celik *et al.* (2000) found that increasing levels of ZnEDTA, $ZnSO_4.7H_2O$ and $ZnCl_2$ in soil system significantly increased Zn concentration in maize plant. It was also noted that the highest dry matter production was obtained with $ZnCl_2$ and ZnEDTA as compared to the control.

Generally, enhancement in concentration of Zn in grains are presently a high priority objective in many countries because Zn deficiency is also a critical problem in human nutrition. High consumption of cereal foods with low concentrations and bioavilabilities of Zn has been a major reason for widespread occurrence of Zn deficiency in humans (Graham and Welch, 1995).

The aim of this research is to:

1- Study the effects of both the different rates and sources of Zn on grain and straw yield of rice (Giza 178) grown on alluvial clay soil and grain Zn concentrations.
2- Determine the fractionation of soil Zn in different stage of rice development.
3- Examine some of the factors affecting the distribution of Zn between the fractions.
4- Relationships between Zn concentrations in individual fractions and Zn concentration in rice crop due to added Zn source.

MATERIALS AND METHODS

A greenhouse experiment was conducted to fulfill the objectives of this study. A randomize complete black design with three replicated of plastic pots with a height of 30 cm and a diameter of 25 cm filled with 10 kg of air-dried soil sample. The soil characterized by pH 7.59, E.C. 2.2 dsm^{-1} at 25°C, clay content 47.3 %, silt 31.5 %, fine sand 14.7 %, coarse sand 6.5 % $CaCO_3$ 4.5 % content, organic matter content 1.03 %, available P 15.5 ppm available N 0.12 ppm, available Fe 1.88 ppm, and available Zn 0.5 ppm.

The fertilizers treatments were as follows : no fertilizer (control), four levels of Zn (1.5, 3.0, 6.0 and 12.0 mg/kg soil) from different Zn sources, as $ZnSO_4.7H_2$, $ZnCl_2$ and ZnEDTA. All pots were fertilized with N, P and K at the following rates respectively 0.6 g N. pot as urea, 0.5 g. pot super-phosphate *and 0.4g. K_2O pot as potassium sulphate. $MnSO_4$, $CuSO_4$ and Fe-EDTA* were applied at a rate of 5, 5 and 2.5 $mg.kg^{-1}$ soil. Thirty days old rice (Giza

178) seedlings were transplanted. Continuous submerged conditions were maintained throughout the growth period of rice.

After the growth period, the plant samples were cut at 2 cm from the soil surface and separated into grain and straw. The plant materials were dried at 70°C until constant weight of these materials, weighted and ground to pass through a 1 mm sieve and stored for analysis. The samples were then digested and analyzed for their contents of N,P and K as a macronutrients and Zn, Mn and Fe as a micronutrients using the standard method by Cottenie *et al.* (1982).

Soil and plant samples taken from the experimental pots at 45, 75 days and maturity stage for fractionation of soil Zn, the methods for fractionation of soil Zn proposed by El-Sokkary (1979) (Table 1) and determined Zn concentration in plant samples. Particle size distribution and chemical properties of the soils used were estimated by the standard methods, Black (1982).

Table (1) : Sequential extraction method for the determination of forms of zinc in soils. (El- Sokkary 1979).

Step fraction	Extractant	Soil:Solution g : ml	Conditions
1. Soil solution and Exchangeable zinc (Zn-CA)	0.05 $MCaCL_2$	1 : 10	Shaken 24 h.
2. Zinc specifically sorbed by inorganic sites (Zn-ACC)	25 % acetic acid	1 : 40	Shaken 24 h.
3. Zinc specifically sorbed by organic sites (Zn-PYR)	0.1 M potassium pyrophosphate	1 : 40	Shaken 24 h.
4. Zinc occluded by free oxides (Zn-OX)	0.1 M oxalic acid + 0.175 Mammonium oxalate pH 3.25	1 : 20	Shaken 2.5 h.
5. Total zinc	Digested with a conc. HNO_3-$HClO_4$ mixture		

Total zinc contents in soils were determined using HCL-HNO_3 digestion method as recommended by Cottenie *et al.* (1982) while available Fe and Zn were extracted by DTPA solution according to Lindsay and Norvall (1978).

Data obtained were subjected to standard analysis of variance procedure (Snedecor and Cochran (1969).

RESULTS AND DISCUSSION

I. Effect of different zinc sources and rates on dry matter yield of rice plant :

The obtained results in Table (2) reveal that the different sources of Zn increased the yield of grain and straw as compared with the control. It was also noted that the highest yield production was obtained with $ZnCl_2$ and ZnEDTA treatments as compared to control the treatment. Nevertheless, $ZnSO_4.7H_2O$ had slightly effective treatment to increase rice yield. ZnEDTA and $ZnCl_2$ sources lead to increase the grain production to 82 and 85 % over the control treatment, the corresponding values for straw were 128 and 135 % respectively. Meanwhile, the increasing of grain and straw, by $ZnSO_4.7H_2O$, were only reached 45 and 81 % respectively. The same trend was observed by Celik *et al.* (2000) and Katkat *et al.* (2000). This inferior effect of Zn SO_4. $7H_2O$ source could be attributed to the rapid solubility and precipitation by soil materials.

Table (2) : Average of grain and straw yields (g/pot) affected by different rates and sources of zinc.

Treatments Zn-source	Zn-rate	Grain yield	Straw yield	Grain/straw ratio	Weight of plant
Control		25.10	29.34	0.86	54.44
$ZnSO_4.7H_2O$	1.5	31.17	41.60	0.75	72.77
	3.0	35.33	46.04	O.77	81.34
	6.0	41.29	50.26	0.82	91.55
	12.0	37.53	74.39	0.50	111.92
Mean		36.33	53.07		89.40
$ZnCl_2$	1.5	54.06	83.59	0.65	137.65
	3.0	48.35	67.38	0.72	115.73
	6.0	43.98	58.53	0.75	102.46
	12.0	40.49	58.39	0.69	98.88
Mean		46.72	66.97		113.68
ZnEDTA	1.5	37.45	61.2 1	0.61	98.66
	3.0	44.51	67.11	0.66	111.62
	6.0	54.41	77.46	0.70	131.87
	12.0	46.23	70.00	0.66	116.23
Mean		45.65	68.95		114.60
L.S.D. 0.01 %		2.93	6.44		

Also, Table (2) shows that the different Zn rates increased grain and straw yield over the control. Data indicated that the highest values (85 %) of grain yield increase was observed at 6 mg Zn.kg^{-1} soil rate, while the highest values (130 %) of straw yield increase was observed at 12 mg Zn. Kg^{-1} soil rate.

Nutritional status of plants :

The obtained data in Table (3) show that N, P and K contents of different parts of the studied plant expressed as uptake was positively affected by addition of the studied Zn fertilizers compared with the control. Moreover, results showed that ZnEDTA was superior to increase N, P and K uptake by grain, while $ZnCl_2$ fertilizer was superior to increase P and K uptake by straw. It was assumed that NPK fertilizer were applied with ZnEDTA and $ZnCl_2$ sources had a vital role in enhancing the N, P and K uptake by different organs of rice. But $ZnSO_4.7H_2O$ source played a small role on the development of N, P and K uptake but not so promising in comparison to ZnEDTA and $ZnCl_2$.

The calculation percentage increase of N, P and K in grain by using $ZnSO_4.7H_2O$ $ZnCl_2$ and ZnEDTA fertilizers are reached 78, 137 and 142% for N, 93, 158 and 166 % for P and reached 23, 54 and 90 % for K respectively. Meanwhile, the corresponding values in straw part reached 247, 436 and 624 for N, 220, 352 and 322 % for P and reached 267, 288 and 278 % for K.

Obtained data declare that the amount of N, P and K uptake in grain were increased with increasing zinc rates from 1.5 to 6 mg Zn. Kg^{-1} soil for all studied fertilizers. While in straw part corresponding values of N and K uptake increased by increasing Zn rates from 1.5 to 12 mg Zn. Kg^{-1} soil with the exception of P. The calculated percent increase in N, P and K uptake by grain as affected by increasing Zn level from 1.5 to 12 mg Zn. Kg^{-1} soil over the control were 82, 118, 152 and 124 % for N, 124, 141, 155 and 142 % for P and 29, 54, 76 and 63 % for K respectively. Meanwhile, the corresponding values reached in straw 317, 377, 493 and 555 % for N, 247, 291, 370 and 284 for P and 216, 256, 319 and 320 for K.

Table (3) : Effect of different application zinc forms and rates on N,P,K uptake (mg/pot) by grain and straw yield of rice crop.

Zn-source	Zn- rate	Straw N	Straw P	Straw K	Grain N	Grain P	Grain K
Control		73.4	50.5	475.0	266.1	61.4	223.4
$ZnSO_4.7H_2O$	1.5	120.6	86.7	1127.4	370.9	104.6	212.0
	3.0	170.4	137.8	1505.5	448.7	120.6	254.4
	6.0	206.1	166.9	1678.7	545.0	143.1	301.4
	12.0	520.7	254.7	2655.7	532.9	135.2	330.3
Mean		254.5	161.5	1741.8	474.4	125.9	274.5
$ZnCl_2$	1.5	351.1	264.1	1956.0	621.7	179.5	340.6
	3.0	316.7	260.5	1792.3	633.4	162.9	343.3
	6.0	433.1	359.9	1984.2	650.2	150.1	333.9
	12.0	473.0	128.6	1637.9	619.5	140.5	360.4
Mean		393.5	253.3	1842.6	631.2	158.3	344.6
ZnEDTA	1.5	446.8	174.3	1414.0	460.6	128.9	314.6
	3.0	563.7	194.4	1771.7	654.0	160.8	436.2
	6.0	666.2	285.4	2300.6	821.0	205.7	544.1
	12.0	448.0	198.5	1694.0	633.4	169.2	402.2
Mean		531.2	213.2	1795.1	642.3	166.2	424.3
L.S.D. at 0.05 %		52.47	68.8	359.7	15.49	53.75	42.5

Table (4) show That Zn concentrations in the rice tissues were increased by adding Zn sources as compared with the control. Moreover, Zn concentration was always higher in straw than its in the grain. The same trend was reported by Prasad and Umar (1993).

Table (4) : Effect of different application zinc forms and rates on Fe, Zn, Mn concentration ($mg.kg^{-1}$) in straw and grain yield of rice plant.

Zn-source	Zn-rate	Straw Fe	Straw Zn	Straw Mn	Grain Fe	Grain Zn	Grain Mn
Control		746.6	25.9	99.6	536.0	19.6	60.6
$ZnSO_4.7H_2O$	1.5	323.6	35.9	107.7	123.9	32.9	228.8
	3.0	440.8	38.7	188.4	174.2	34.4	282.7
	6.0	589.6	41.8	161.5	222.2	36.8	134.6
	12.0	614.3	34.3	148.1	358.3	32.7	80.8
Mean		492.1	37.7	151.4	219.7	34.2	181.7
$ZnCl_2$	1.5	580.1	42.0	403.8	211.3	30.3	251.3
	3.0	710.5	44.3	336.5	225.4	32.8	134.6
	6.0	660.4	40.9	329.3	214.2	30.3	121.2
	12.0	474.1	32.2	276.9	176.1	28.1	107.7
Mean		606.3	39.9	336.6	206.8	30.4	153.7
ZnEDTA	1.5	391.6	32.3	134.6	309.1	27.5	134.6
	3.0	457.9	41.8	161.5	356.9	31.2	129.6
	6.0	462.3	44.1	143.3	411.1	35.8	118.7
	12.0	461.2	41.5	117.3	291.2	32.3	108.4
Mean		443.3	39.9	139.2	342.1	31.7	122.8
L.S.D. at 0.05 %		2.26	2.27	2.30	2.39	2.36	2.22

A comparison among Zn Sources the data showed that the large increase in Zn concentration and Zn uptake in straw were obtained with ZnEDTA and $ZnCl_2$ at various rates as compared to $ZnSO_4.7H_2O$. Moeover, $ZnSO_4.7H_2O$ was slightly effective to increase Zn status. Similar results were obtained by Celik *et al.* (2000). Data reveal that application of $ZnSO_4.7H_2O$ source had highest Zn concentrations in grain 75 % compared with ZnEDTA and $ZnCl_2$ (62 and 55 %). Therefore, $ZnSO_4.7H_2O$ source may be more effective than other sources to increase Zn concentration in grain. On the other hand Zn EDTA and Zn Cl_2 sources gave the highest Zn-uptake by grain (197 and 189%) compared to Zn SO_4. 7 H_2O source (154%).

Data reveal that Zn concentration in rice tissues was also influenced by Zn level, without supplemental Zn, the concentration of Zn was 25.9 and 19.6 ppm at straw and grain. Whereas, the rate of Zn increased from 1.5 to 6 mg $Zn.kg^{-1}$ soil found Zn concentration increased too. Moreover, the 6 mg $Zn.kg^{-1}$ soil rate was the most efficient rate where it gave 63 and 75 % increase in Zn concentration in straw and grain respectively compared with the control. There was a decrease in Zn response when Zn level was raised from 6 to 12 mg $Zn.kg^{-1}$ soil. This indicated that 6 mg $Zn.kg^{-1}$ soil level was probably sufficient. These results are in agreement with these noted by (Shukla and Raj 1974) and Faiyed (1989) who found that application of Zn to the soil at the rates of 3 and 6 kg increased its concentration and uptake but the rate of 9 kg decreased its concentration.

Data in same Table (4) show that increased Zn application rate than 3 mg $Znkg^{-1}$ soil produced decrease concentration of Mn in straw while in grain the best rate was 1.5 mg $Zn.kg^{-1}$ soil. These results might be attributed to increase amounts of absorbed Zn which affects the absorption of Mn by plants. (El-Kassas and Shahata 1984). A comparison among Zn sources showed that large increase in Mn concentration were obtained with $ZnCl_2$ in straw but in grain found $ZnSO_4.7H_2O$ was superior at various rate, while ZnEDTA being inferior in straw and grain. These results are in agreement with these noted by El-Kassas and Shahata (1984).

Data given in same Table (4) show that iron concentration in rice tissues were higher in control when no zinc added. This result may be due to under Zn deficiency conditions, Fe ions seemed to be carries on the sites of Zn (El-Ashry, 1997) or results of the antagonistic effects of Zn upon the absorption of iron either in the soil or on the root surface. Moreover, iron concentrations in rice tissue decreased by zinc fertilizers applied. Generally iron concentration was always higher in straw than its in the grain.

A comparison among Zn sources the data showed that large decrease in Fe concentration were obtained with ZnEDTA (-41 %) in straw while in grain $ZnCl_2$ had the highest decrease (-61 %) at various rates.

The concentration of Zn and percentages of total Zn determined in the individual fractions of the soil are presented in Table (5). The results show that are total soil Zn concentrations ranged from 95.5 to 333.8 $mg.kg^{-1}$. The highest concentrations are associated with soil treated with ZnEDTA at the rate of 12 mg $Zn.kg^{-1}$ soil.

Table (5) : Effect of rice on the changes in different forms of zinc in the soils during growing season.

a) zinc forms in the soil (ppm).

Treatments		Zn-CA	Zn-ACC	Zn-PYR	Zn-OX	Zn-RES	Zn-total
1st							
Control		1.5	6.6	4.0	14.4	96.7	123.2
$ZnSO_4.7H_2O$	1.5	1.8	6.3	4.3	7.9	127.5	147.8
	3.0	2.6	7.8	4.2	17.7	124.2	156.5
	6.0	2.1	6.9	6.8	15.9	206.8	238.5
	12.0	1.8	7.7	4.8	18.3	215.4	247.8
$ZnCl_2$	1.5	2.4	11.8	4.5	5.0	101.7	125.3
	3.0	1.2	7.4	7.0	9.3	125.4	150.3
	6.0	0.8	11.0	4.8	13.4	149.3	179.3
	12.0	0.6	8.7	5.0	25.7	220.6	260.8
ZnEDTA	1.5	1.3	10.2	4.2	7.3	138.5	161.5
	3.0	1.8	13.6	4.5	12.3	174.7	206.8
	6.0	2.2	12.8	5.1	13.9	172.8	206.8
	12.0	2.9	10.8	6.6	14.3	299.2	333.8
2nd							
Control		1.7	11.5	9.0	10.4	88.3	120.9
$ZnSO_4.7H_2O$	1.5	3.3	17.2	9.7	9.9	58.2	98.3
	3.0	4.3	13.7	8.4	12.1	77.5	116.0
	6.0	2.3	13.7	10.0	20.1	183.2	229.3
	12.0	3.9	10.2	11.4	16.2	197.8	239.5
$ZnCl_2$	1.5	3.3	11.3	11.6	3.2	51.4	80.8
	3.0	7.7	9.9	10.6	6.9	96.7	131.8
	6.0	3.7	11.3	11.6	11.8	124.9	163.3
	12.0	14.5	11.2	6.7	36.2	128.9	197.5
ZnEDTA	1.5	3.6	10.1	18.0	9.9	55.9	97.5
	3.0	4.4	12.4	16.4	15.9	60.4	109.5
	6.0	4.6	11.9	15.7	14.9	130.2	177.3
	12.0	4.8	11.0	12.7	6.5	147.0	182.0
3rd							
Control		1.4	7.5	10.4	11.8	84.9	116.0
$ZnSO_4.7H_2O$	1.5	2.9	10.1	8.7	12.1	47.0	80.8
	3.0	2.5	10.7	13.4	9.4	56.0	92.0
	6.0	4.3	14.9	15.3	11.9	179.6	226.0
	12.0	5.2	11.3	18.4	9.8	186.3	231.0
$ZnCl_2$	1.5	5.2	11.8	14.0	3.9	35.1	70.0
	3.0	5.7	12.6	17.8	6.7	48.2	91.0
	6.0	3.2	13.4	23.7	11.1	53.6	105.0
	12.0	5.8	11.7	17.9	19.2	91.2	145.8
ZnEDTA	1.5	5.0	14.3	22.7	8.6	44.9	95.5
	3.0	5.3	15.9	25.9	11.2	56.0	114.3
	6.0	5.6	15.4	14.8	8.9	101.8	146.5
	12.0	6.1	12.4	12.8	8.1	124.9	164.3

b) Zinc forms as percentages of total zinc

Treatments		Zn-CA	Zn-ACC	Zn-PYR	Zn-OX	Zn-RES
			1st			
Control		1.2	5.4	3.2	11.7	78.5
$ZnSO_4.7H_2O$	1.5	1.2	4.3	2.9	5.3	86.3
	3.0	1.6	5.0	2.7	11.3	79.4
	6.0	0.9	2.9	2.9	6.6	86.7
	12.0	0.7	3.1	1.9	7.4	86.9
$ZnCl_2$	1.5	1.9	9.4	3.6	4.0	81.2
	3.0	0.8	4.9	4.7	6.2	83.4
	6.0	0.4	6.2	2.7	7.5	83.3
	12.0	0.2	3.3	1.9	9.9	84.6
ZnEDTA	1.5	0.8	6.3	2.6	4.5	85.8
	3.0	0.9	6.6	2.2	5.9	84.5
	6.0	1.1	6.2	2.5	6.7	83.6
	12.0	0.9	3.2	2.0	4.3	89.6
			2nd			
Control		1.4	9.5	7.4	8.6	73.0
$ZnSO_4.7H_2O$	1.5	3.3	17.5	9.9	10.1	59.2
	3.0	3.7	11.8	7.2	10.5	66.8
	6.0	1.0	6.0	4.4	8.8	79.9
	12.0	1.6	4.3	4.8	6.8	82.6
$ZnCl_2$	1.5	4.1	14.0	14.4	3.9	63.6
	3.0	5.8	7.5	8.1	5.2	73.4
	6.0	2.3	6.9	7.1	7.2	76.5
	12.0	7.3	5.7	3.4	18.3	65.3
ZnEDTA	1.5	3.7	10.4	18.4	10.2	57.3
	3.0	4.0	11.3	15.0	14.5	55.2
	6.0	2.6	6.7	8.8	8.4	73.5
	12.0	2.6	6.0	7.0	3.6	80.8
			3rd			
Control		1.2	6.5	9.0	10.2	73.2
$ZnSO_4.7H_2O$	1.5	3.6	12.5	10.8	15.0	58.2
	3.0	2.7	11.6	14.6	10.2	60.9
	6.0	1.9	6.6	6.8	5.2	79.5
	12.0	2.3	4.9	8.0	4.2	80.6
$ZnCl_2$	1.5	7.4	16.9	20.0	5.6	50.1
	3.0	6.2	13.9	19.6	7.4	53.0
	6.0	3.1	12.7	22.5	10.5	51.0
	12.0	4.0	8.0	12.3	13.2	62.6
ZnEDTA	1.5	5.3	14.9	23.8	9.0	47.0
	3.0	4.6	13.9	22.6	9.8	49.0
	6.0	3.8	10.5	10.1	6.0	69.5
	12.0	3.7	7.5	7.8	4.9	76.0

Although there were clearly differences between fertilizers added in the proportional distribution of Zn between individual fractions. On average, relatively small proportions of Zn are present as soil solution and exchangeable from 0.2 to 7.4 % which represents the most readily available source of Zn, Zn specifically sorbed by inorganic sites (2.9 – 17.5 %). These higher levels probably resulted from the dissolution of some precipited Zn by the acetic acid, Zn specifically sorbed by orgain sites (1.0 – 20.0 %) which is known to play a significant role in Zn nutrition of low land rice (Mandal and Mandal 1986) and Sims and Patrick (1978) have observed that zinc mobilized under reducing conditions in the soil becomes associated with organic matter, while zinc occluded by free oxides (3.9 – 18.3 %) of total Zn.

However, on average (54.2 – 85.9 %) of total zinc was present in the residual fraction. This fraction is considered to consist mainly of Zn present in primary and secondary silicate minerals, or associated with refractory organic materials, and is there for extremely inert and completely unavailable for plant uptake.

The results are generally in agreement with other previously published data, Haynes and Swift (1984) and Shuman (1985) have reported that the greatest proportions (generally above 50 % of soil micronutrients) occur in the residual fraction. Also, El-Sokkary (1979) reported that for twenty nine alluvial soils from Egypt, an average of 45.4% of the total soil Zn occurred in the residual fraction. For lowland rice soils, Mandal and Mandal (1986) reported an even greater proportion (above 90 %) of Zn present in the residual fraction.

Table (6) shows that Zn concentration in rice plant highly significant positive correlation with residual zinc in first and second period with exception ZnEDTA fertilizer at second period. Although, the residual fraction is considered completely unavailable for plant uptake, the plant root-induced change in the rhizosphere for availability of micronutrients (Marschner, 1991) and release of non protein gonenic amino acids, so called phytosiderophores form graminaceous species (Takagi *et al.*, 1988), which are effective in enhancing the mobilization of zinc (Zhang *et al.*, 1991). These compounds form stable chelates not only with iron (Fe III) but also with zinc and copper and are as effective as DTPA in mobilizing zinc.

Table (6) : Correlation coefficients (r) between changes in different forms of zinc and zinc in soil concentration in rice plant.

Fertilizers treatment	Zn-CA	Zn-ACC	Zn-PYR	Zn-OX	Zn-RES
			1st		
$ZnSO_4.7H_2O$	0.22^{ns}	0.16^{ns}	0.84^{***}	0.23^{ns}	0.73^{**}
$ZnCl_2$	0.67^{**}	0.36^{ns}	0.13^{ns}	0.68^{**}	0.92^{***}
ZnEDTA	0.85^{***}	0.66^{**}	0.87^{***}	0.34^{ns}	0.90^{***}
			2nd		
$ZnSO_4.7H_2O$	0.09^{ns}	0.52^{*}	0.16^{ns}	0.55^{**}	0.74^{**}
$ZnCl_2$	0.59^{*}	0.13^{ns}	-0.23^{ns}	0.67^{**}	0.79^{***}
ZnEDTA	0.95^{***}	0.11^{ns}	0.70^{**}	0.25^{ns}	0.40^{ns}
			3rd		
$ZnSO_4.7H_2O$	0.61^{*}	0.87^{***}	0.40^{ns}	0.22^{ns}	0.27^{ns}
$ZnCl_2$	0.20^{ns}	0.52^{*}	0.72^{**}	0.25^{ns}	0.06^{ns}
ZnEDTA	0.88^{***}	0.80^{***}	0.26^{ns}	-0.52^{*}	0.34^{ns}

Meanwhile, in the third period the obtained data show that zinc concentration in rice plant highly significant positive correlation with the zinc specifically sorbed by inorganic sites (Zn-ACC) which is assumed to the most available fraction of soil zinc and due to its extremely low level in the soil, they are considered to have inadequate Zn supply for normal plant growth. The (ZnACC) fraction which is mostly associated with soil carbonates might be more available than the Zn-PYR and Zn-OX fractions. Allen and Terman (1966) and Boawn *et al.* (1957) reported that this fraction might acts as a reservoir for supplying the plants with zinc. In this instance El-Sokkary (1979) showed that the rate of utilization of Zn-ACC would depend on several factors i.e., soil texture, the pattern of the plant root system.

CONCLUSIONS

It could be concluded that the application of Zn EDTA source at 6 mg Zn. Kg^{-1} soil rate was sufficient to produce a high rice yield and increase grain Zn uptake.

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تأثير المصادر والمعدلات المختلفة من الزنك على محتوى محصول الارز على الزنك وبعض العناصر الاخرى

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اجريت تجربة زراعية لدراسة تأثير اضافة الزنك بمعدلات ومصادر مختلفة على محصول الارز (صنف ١٧٨) من القش والحبوب وللتعرف على اكثر المصادر والمعدلات فاعلية فى زيادة محتوى الحبوب من الزنك حيث ان نقص الزنك فى الحبوب التى يتناولها الانسان يؤدى الى حدوث مشكلة حرجة فى تغذيته :

-ادى اضافة المصادر المختلفة من الزنك الى زيادة محصول كل من الحبوب والقش مقارنا بالكنترول وكان لسماد كبريتات الزنك التأثير الاقل فى زيادة المحصول مقارنا بكلوريد الزنك والزنك المخلبى .

-كما تأثر المحصول بمعدلات اضافة الزنك حيث انها زاد بزيادة معدلات الاضافة فكان اقصى زيادة فى الحبوب (٨٥ %) تم التحصل عليها عندمعدل اضافة ٦ ملليجرام زنك اما بالنسبة للقش فكان اعلى زيادة (١٣٠ %) تم الحصول عليها عند معدل اضافة ١٢ ملليجرام زنك.

-اما معدل امتصاص النيتروجين والفوسفور والبوتاسيوم فى كلا من القش والحبوب فقد كان مرتبطا ارتباطا موجبا باضافة الاسمدة المدروسة .

-ولقد وجدان تركيز الزنك فى اجزاء الارز المختلفة قد زاد باستخدام الاسمدة المدروسة مقارنا بالكنترول ولقد لوحظ ان اعلى زيادة فى تركيز الزنك فى القش عندما استخدام سمادى كلوريد الزنك والزنك المخلبى (ZnEDTA) بينما فى الحبوب وجد ان اعلى زيادة كانت فى حالة استخدام سماد كبريتات الزنك –وعموما كان معدل الاضافة الامثل والاكثر فاعلية فى زيادة تركيز الزنك فى القش والحبوب هو ٦ ملليجرام زنك/كيلو تربة وبزيادة معدل الاضافة عن ذلك تقل استجابة النباتات لهذه الزيادة .

الخلاصة : توضح النتائج انه يمكن استخدام سماد الزنك المخلبى (ZnEDTA) وبمعدل ٦ ملليجرام زنك/كيلو تربة للحصول على اعلى محصول للحبوب وعلي اعلي امتصاص للزنك بواسطة الحبوب.