INFLUENCE OF ORGANIC MATTER ON THE RELEASE OF ZINC FROM LATERITE SOIL

by M. Adhikari *and* S. K. Gupta, *Department of Applied Chemistry, Calcutta University, Calcutta*

(Communicated by Dr. S. P. Raychaudhuri, F.N.A.)

(*Received 23 September 1977*)

The rclease of trace elements was significantly guided by organic matter addition. The effect of N, P addition towards Zn^{++} release was similar to that of Cu^{++} and the mutual interactions of Cu^{++} and Zn^{++} significantly influenced each other.

Introduction

The factors affecting the availability of zinc are *p*H, phosphorus, organic matter (Thorne 1957). A significant positive relation between organic matter and the availability of zinc was noticed by various workers (Agboola & Corey 1973; Macias 1973; and Jenson & Lamm 1961). The increased availability of zinc with higher organic matter content of soil is due to zinc content of organic matter itself and also to changed *p*H (Camp 1945; and Matsuda & Ikuta 1969).

Nikitin and Raincy (1952); and Bandyopadhyaya and Adhikari (1968) reported that high rates of N and P increased the availability of zinc. Phosphorus addition usually gives rise to Zn-deficiency and restricts Zn-availability (Eillis *et al.* 1964; and Melton *et al.* 1967). Boawn *et al.* (1960) confirmed that N-fertilization increased Zn-uptake. Navrot and Raikovitch (1969) pointed that the adsorption of Zn^{++} by plant from soil was affected by particle size of $CaCO_3$. Nitrates of alkaline earth cations depressed the Zn-sorption in the order $Mg^{++} > Ba^{++} > Sr^{++} = Ca^{++}$ (Chaudhury & Longeragan 1972). Agboola and Corey (1973) showed a positive correlation between available zinc and copper. At a very low concentration of Ca^{++}, both H^{+} and Cu^{++} retarded Zn-adsorption.

An attempt is made here to find out the influence of organic matter fraction (humic acid and fulvic acid) along with macro and micro-nutrients (Ca^{++}, Mg^{++}, Cu^{++}, Zn^{++}) on the release of zinc in laterite soil of Purulia.

Materials and Methods

Soil sample was collected as usual (0 to 15 cm. depth) from Purulia, a laterite zone in West Bengal. Some of its physical and chemical properties are put down in Table I (Adhikari & Ganguli 1971). The organic matter from Padegoan soil (Poona, Padegoan, Maharashtra) was extracted and fractionated following the procedures of Adhikari & Ganguli (1971). Some physico-chemical aspects of different fractions of organic matter are given in Table I. Soil samples were freed from organic matter

TABLE I

Some physical and chemical properties of Purulia soil (Original)

Colour of soil : Reddish Brown : 5YR/4/R

Mechanical Analysis							
Sand	51.48%	*p*H : 5.50; Equivalent conductance in mho/cm 0.34					
Coarse sand	20.00%	Percentages of :					
Silt	5.74%	Total Fe_2O_3	:	7.60	R_2O_3	:	22.96
Clay	21.96%	Free Fe_2O_3	:	2.32	Al_2O_3	:	15.69
Unaccountable and ignition loss	0.82%	Total CaO	:	1.15	CuO	:	0.05
		SiO_2/R_2O_3 Ratio	:	1.36			
Grand Total	100.00%						

Cation exchange capacity	:	14.9612 m.eqv. %
Total specific surface area	:	212.15 in m^2/g
Internal	:	10.50 ,,
External	:	8.20%
Exchangeable Aluminium (Al^{3+})	:	2.50%
Exchangeable Iron (Fe^{3+})	:	1.29%
$CaCO_3$	:	1.56%
Oxidizable matter in terms of 0.01 (N) $KMnO_4$/g soil	:	5.55%

Analysis of organic matter fractions from Padegoan soil (Black cotton) predominant inmontmo rillonite

	Humic Acid	Fulvic Acid
Total Carbon	66.93%	34.55%
Total Nitrogen	6.51%	3.31%
Total Phosphorus	0.635%	0.432%

Some chemical characteristics of Purulia soil after removal of organic matter

Expressed in mg/100 g soil

Total Nitrogen (Kjeldah)	:	33.7850	Extractable Phosphorus	:	3.25
Extractable Nitrogen	:	32.5675	Exchangeable Phosphorus	:	3.07
Exchangeable Nitrogen	:	33.2436	Available Phosphorus	:	1.63
Distillable Ammonia	:	5.6312			

Different nutrient contents in Purulia soil (Original)

Total Calcium	:	3.25%	Exchangeable Calcium (m.eqv %)	:	9.20
Total Magnesium	:	1.06%	Exchangeable Magnesium (m.eqv. %)	:	3.20
Total Copper	:	30.50 ppm	Exchangeable Copper (ppm)	:	9.87
Total Zinc	:	83.70 ppm	Exchangeable Zinc (ppm)	:	12.50

and treatments of nutrients were made according to Adhikari & Ganguly (1971). Some physico-chemical properties of organic matter free soil (OMF) of Purulia are also included under Table 1. To O.M.F. soil the following treatments were made :

(*i*) *Carbon, nitrogen and phosphorus* were equalled to the original C, N, P content of soil (Purulia).
(*ii*) *Calcium and Magnesium* were equalled to the available calcium and magnesium content of original soil (Purulia).
(*iii*) Copper and zinc were applied in 3 dosages according as 50%, 25%, 10% of CEC equivalent to original soil.

Two fractions of humus were applied alternatively as source of carbon : (*i*) humic acid (HA) and (*ii*) fulvic acid (DA). Nitrogen was applied alternative to phosphorus. Humic acid was applied alternative to fulvic acid. Other treatments remained same. For each type of leachate, the following 4 sets of treatments were made :

(*i*) N, HA, Ca, Mg, Cu (at 3 dosages), Zn (at 3 dosages)
(*ii*) N, FA, Ca, Mg, Cu (at 3 dosages), Zn (at 3 dosages)
(*iii*) P, HA, Ca, Mg, Cu (at 3 dosages), Zn (at 3 dosages)
(*iv*) P, FA, Ca, Mg, Cu (at 3 dosages), Zn (at 3 dosages)

The following denotations are used in all the Tables (Analysis of Variance) II (1) to II (4) :—

(*a*) In case of carbon, nitrogen, phosphorus, calcium, magnesium : 0 level signifies absence and 1 signifies presence of the same.

(*b*) In case of copper, zinc : 0 level signifies absence whereas 1, 2, 3 signify respectively the dosages of 50%, 25%, 10% equivalent to CEC.

Extractable zinc was determined (Dolar & Keeney 1971) in 3 leachates :

1 (N) Mg $(NO_3)_2$ at *p*H 5.90

0.01 (M) EDTA in N (NH_4) OAC at *p*H 7.0

0.1 (M) HCl at *p*H 1.00.

But for the sake of economy, and space, *'Analysis of Variance'* in case of only one leachate (N) Mg $(NO_3)_2$ at *p*H 5.90 is given in Tables II (1) to II (4). All the three leachates showed well comparable results and the trend was found identifical in all 3 cases.

Results and Discussion

The release of zinc in all three leachates from treated Purulia soil samples showed that fulvic acid was more efficient than humic acid fraction.

Extractable Zn^{++} increased with the application of organic matter in all possible treatments and at all levels. Boawn *et al.* (1960) and Dolar and Keeney (1971) found that nitrogen fertilization improved the Zn-uptake of soil. The present study confirmed the findings. Khan (1969) showed that phosphorus treatments reduced the

TABLE II (1)

Analysis of Variance

[Release of zinc in 1 (N) $Mg(NO_3)_2$ at pH 5.90]

Treatments	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio
Zn	103800.00	3	34610.00	78.10
Cu	440.80	3	146.90	33.05
N	673.90	1	673.90	151.80
Zn N	331.90	3	110.60	24.90
Zn Cu	254.40	9	28.27	6.64
Cu N	102.90	3	34.31	7.74
Zn Cu N	38.79	9	4.31	9.74
O	328.90	1	328.90	77.40
Zn O	554.70	3	184.90	41.60
Cu O	94.25	3	31.41	7.08
Zn Cu O	160.40	9	17.82	4.02
N O	66.11	1	66.11	14.94
Zn N O	75.88	3	25.29	5.71
Cu N O	1.50	3	0.50	0.11
Ca	281.30	1	281.30	63.50
Zn Ca	379.30	3	126.40	28.50
Cu Ca	3.08	3	1.02	0.23
Zn Cu Ca	12.64	9	0.14	0.03
N Ca	16.99	1	16.99	3.83
Zn N Ca	59.28	3	19.76	4.46
Cu N Ca	21.76	3	7.25	1.63
O Ca	0.07	1	0.07	0.01
Zn O Ca	49.55	3	16.51	3.72
Cu O Ca	3.29	3	1.09	0.24
N O Ca	0.42	1	0.42	0.09
Mg	0.32	1	0.32	0.07
Zn Mg	274.70	3	91.57	20.70
Cu Mg	6.57	3	2.19	0.49
Zn Cu Mg	5.81	9	0.64	0.14
N Mg	66.79	1	66.79	15.08
Zn N Mg	46.37	3	15.45	3.49
Cu N Mg	44.15	3	14.71	3.32
O Mg	16.00	1	16.00	3.61
Zn O Mg	73.16	3	24.38	5.50
Cu O Mg	27.74	3	9.24	2.08
N O Mg	8.43	1	8.43	1.90
Ca Mg	208.70	1	208.70	47.40
Zn Ca Mg	238.90	3	79.65	18.00
Cu Ca Mg	11.51	3	3.83	0.86
N Ca Mg	25.62	1	25.62	5.79
O Ca Mg	0.78	1	0.78	0.76
Residual	576.02	130	4.43	

TABLE II(2)

Analysis of Variance

[Release of Zinc in 1 (N) $Mg(NO_3)_2$ at pH 5.90]

Treatments	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio
Zn	68940.00	3	22980.00	43.40
Cu	679.40	3	226.40	42.90
Zn Cu	740.10	9	82.24	15.55
P	969.10	1	969.10	183.00
Zn P	2742.00	3	914.00	172.50
Cu P	95.04	3	31.68	5.99
Zn Cu P	409.00	9	45.45	8.53
O	29.03	1	29.03	5.48
Zn O	68.97	3	23.32	4.40
Cu O	21.94	3	7.31	1.38
Zn Cu O	136.40	9	15.15	2.86
P O	145.40	1	145.40	27.45
Zn P O	204.90	3	68.31	12.89
Cu P O	85.30	3	28.43	5.35
Ca	147.40	1	147.40	27.80
Zn Ca	223.50	3	74.53	15.05
Cu Ca	34.67	3	11.55	2.18
Zn Cu Ca	72.32	9	8.03	1.51
P Ca	146.00	1	146.00	27.60
Zn P Ca	114.80	3	38.27	7.23
Cu P Ca	5.92	3	1.97	0.37
O C a	20.37	1	20.37	3.83
Zn O Ca	25.31	3	8.43	1.59
Cu O Ca	26.66	3	8.88	1.68
P O Ca	0.05	1	0.05	0.01
Mg	360.80	1	360.80	68.10
Zn Mg	243.80	3	81.29	15.35
Cu Mg	11.96	3	3.98	0.75
Zn Cu Mg	25.02	9	2.78	0.52
P Mg	15.11	1	15.11	2.85
Zn P Mg	52.98	3	17.66	3.34
Cu P Mg	14.50	3	4.83	0.91
O Mg	1.50	1	1.50	0.28
Zn O Mg	6.47	3	2.15	0.40
Cu O Mg	1.84	3	0.61	0.11
P O Mg	5.39	1	5.39	1.01
Ca Mg	176.40	1	176.40	33.10
Zn Ca Mg	165.30	3	55.10	10.39
Cu Ca Mg	32.25	3	10.75	2.03
P Ca Mg	91.86	1	91.86	17.30
O Ca Mg	2.42	1	2.42	0.45
Residual	688.55	130	5.29	

TABLE II(3)

Analysis of Variance

[Release of Zinc in 1 (N) $Mg(NO_3)_2$ at pH 5.90]

Treatments	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio
Zn	104400.00	3	34800.00	9090.60
Cu	481.90	3	160.60	41.90
Zn Cu	252.20	9	28.03	7.32
N	596.30	1	596.30	155.80
Zn N	368.10	3	122.70	32.02
Cu N	78.50	3	26.16	6.82
Zn Cu N	38.04	9	4.22	1.10
Q	107.00	1	107.00	27.91
Zn Q	568.40	3	189.40	49.50
Cu Q	74.51	3	24.83	6.49
Zn Cu Q	176.30	9	19.59	5.11
N Q	93.51	1	93.51	24.41
Zn N Q	49.50	3	16.50	4.31
Cu N Q	1.03	3	0.34	0.09
Ca	336.20	1	336.20	87.70
Zn Ca	315.00	3	105.00	27.40
Cu Ca	0.67	3	0.22	0.05
Zn Cu Ca	5.77	9	0.64	0.16
N Ca	34.89	1	34.89	9.11
Zn N Ca	41.77	3	13.92	3.63
Cu N Ca	34.01	3	11.33	2.96
Q Ca	3.44	1	3.44	0.89
Zn Q Ca	19.86	3	6.62	1.73
Cu Q Ca	2.87	3	0.95	0.25
N Q Ca	5.91	1	5.91	1.54
Mg	273.70	1	273.70	71.30
Zn Mg	275.10	3	91.70	23.90
Cu Mg	2.10	3	0.70	0.18
Zn Cu Mg	6.72	9	0.74	0.19
N Mg	45.79	1	45.79	11.65
Zn N Mg	73.99	3	24.66	6.45
Cu N Mg	31.32	3	10.44	2.73
Q Mg	6.25	1	6.25	1.63
Zn Q Mg	35.32	3	11.77	3.07
Cu Q Mg	17.72	3	5.90	1.51
N Q Mg	2.25	1	2.25	0.58
Ca Mg	262.60	1	262.60	68.50
Zn Ca Mg	204.20	3	68.09	17.80
Cu Ca Mg	18.03	3	6.01	1.57
N Ca Mg	46.89	1	46.89	12.25
Q Ca Mg	6.94	1	6.94	1.81
Residual	497.89	130	3.82	

TABLE II(4)

Analysis of Variance

[Release of Zinc in 1 (N) $Mg(NO_3)_2$ at pH 5.90]

Treatments	Sum of Squares	Degree of Freedom	Mean Squares	F Ratio
Zn	69750.00	3	23250.00	44.60
Cu	683.00	3	227.60	43.60
Zn Cu	748.70	9	83.19	15.94
P	1049.00	1	1049.00	201.50
Zn P	2712.00	3	904.10	1.73
Cu P	91.89	3	30.63	5.87
Zn Cu P	411.70	9	45.74	8.78
Q	102.20	1	102.20	19.60
Zn Q	95.39	3	31.79	6.10
Cu Q	21.12	3	7.04	1.35
Zn Cu Q	133.80	9	14.86	2.86
P Q	116.30	1	116.30	22.30
Zn P Q	210.00	3	70.02	13.40
Cu P Q	85.50	3	28.50	5.48
Ca	146.50	1	146.50	28.10
Zn Ca	214.80	3	71.60	13.70
Cu Ca	38.97	3	12.99	2.49
Zn Cu Ca	69.50	9	7.72	1.48
P Ca	147.40	1	147.40	28.25
Cn P Ca	112.90	3	37.66	7.23
Cu P Ca	5.88	3	1.96	0.37
Q Ca	19.93	1	19.93	3.81
Zn Q Ca	22.53	3	7.51	1.44
Cu Q Ca	32.22	3	10.74	2.06
P Q Ca	0.03	1	0.03	0.00725
Mg	372.10	1	372.10	71.20
Zn Mg	246.20	3	82.08	15.77
Cu Mg	12.17	3	4.05	0.78
Zn Cu Mg	25.46	9	2.82	0.54
P Mg	16.17	1	16.17	3.09
Zn P Mg	54.32	3	18.10	3.46
Cu P Mg	12.90	3	4.30	0.82
Q Mg	2.35	1	2.35	0.45
Zn Q Mg	7.19	3	2.39	0.46
Cu Q Mg	2.13	3	0.71	0.13
P Q Mg	6.08	1	6.08	1.16
Ca Mg	181.60	1	181.60	34.80
Zn Ca Mg	174.00	3	58.01	11.10
Cu Ca Mg	29.58	3	9.86	1.89
P Ca Mg	91.65	1	91.65	17.55
Q Ca Mg	3.11	1	3.11	0.59
Residual	678.11	130	5.21	

extractable Zn^{++} in flooded rice soil and Sharpless *et al.* (1969) noticed no significant relation between Zn^{++} and P-availability.

Both Ca^{++} and Mg^{++} treatments decreased Zn^{++} availability. Choudhury & Loneragan (1972) stated that cations rather than anions inhibited Zn-adsorption which is ultimately exchangeable with chelating agent.

In some cases (Agboola & Corey 1973; and Macias 1973) copper uptake is significantly related to Zn-uptake. In the present study, the application of copper increased Zn-availability; copper at 50% CEC equivalent influenced the Zn-uptake most. Some workers (Dolar & Keeney 1971) pointed out that available Zn^{++} was slightly correlated to total Zn. The Tables II (1) to II (4) reveal the fact that increase in Zn^{++} dosaging simply increased the Zn-availability but the fraction of the total amount of Zn^{++} extractable was maximum at 10% level.

The beneficial effect of organic matter indicates that possibly portions of readily exchangeable Zn^{++} get introduced with soil organic matter, much of which is in complex form with dehydrogenated carboxylic groups of humic substances (Schnitzer & Khan 1972; Ellis (Jr.) *et al.* 1964; and Dolar & Keeney 1971). The effect of application of fulvic acid was more pronounced than humic acid in respect of Zn^{++} release and is due to better chelating capacity of the former (Schnitzer & Khan 1972).

Influence on Zn^{++} release with applications of nitrogen is due to greater replacement of NH_4^+ with respect to Zn^{++} and relatively higher fixation of NH_4^+ in clay lattice. The present study confirms the earlier views that diffusion of Zn^{++} in soils is a function of applied Zn, P and soil *p*H (1 ; 2.5). The formation of hydroxide and phosphate is a primary cause of reduced availability of zinc in soils (Misra & Tiwari 1964; and Burleson & Page 1964). Simultaneous application of calcium and phosphorus reduced zinc availability and this is due to hindered adsorption on clay surface (Choudhury & Longeragan 1972). Increase in Zn^{++} availability with Mg^{++} addition is due to mutual competitive fixation of Mg^{++} and Zn^{++} (Bear 1968) in clay surface and isomorphous displacement. The effect of Ca^{++} and $Ca^{++} + Mg^{++}$ can be explained on the basis of oxidation potential. Favoured Zn^{++} release in presence of copper is also because of this difference in oxidation potential of copper i.e., — 0.349 in comparison to Zn/Zn^{++} is + 0.76 (Sekhon & Chopra 1971).

ACKNOWLEDGEMENTS

The authors are thankful to Dr. Basudev Adhikari, Department of Statistics and Dr. Abhijit Sengupta, Department of Radiophysics, Calcutta University for their help in programming and statistical analysis of data in IBM 1135.

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