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Soil Zinc Fractions in a Long Term Cropped and Fertilized Soils in an Acid Alfisol of Ranchi

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Abstract

A study was taken up to assess the various zinc fractions status and their correlation with other soil properties. On average water soluble, exchangeable, specially adsorbed, acid soluble, Mn- occluded, organic matter occluded, amorphous Fe- occluded, crystalline Fe- occluded fractions of zinc contributed very little whereas the residual fraction of Zn was a dominant constituent. The significant positive relationship among different fractions suggests the existence of a dynamic equilibrium of different Zn fractions in soils, while the significant positive relationship of different fraction of Zn with organic carbon, silt and clay suggests the dependence of Zn availability on organic matter content and finer fractions of soils.
Key words : Long term fertilizer experiment, Forms of zinc, Alfisol, Fertilized soils, Zinc fractions.

A different chemical form of trace metals exists in soil and their bioavailability is governed by a dynamic equilibrium among the different fractions of soil Zinc. Water soluble and exchangeable forms are readily available, the organically complexed Mn oxides and amorphous Fe oxides bound forms are potentially available but crystalline Fe oxides bound and the residual fractions are little available to plants. Most of the different fractions of soil zinc showed positive and significant correlation among themselves. The present investigation was undertaken to study the different fractions of zinc and their correlation with different soil properties and different zinc fraction in long term fertilized soils of Ranchi.

Methods

The surface (0—15 cm) soil samples were collected from each treatment after harvest of wheat crop in *rabi* (2000-01) and air dried, processed and analyzed for different soil properties. Different fractions of zinc in ferlilizer and organic manure treated soils were estimated by sequential fractionation method. Total zinc was determined by digesting the soil samples with HNO_3, HF and $HClO_4$ and the residue was dissolved in HCl Zinc extracted by the above method was determined by atomic absorption spectrophotometer.

Results and Discussion

The data on physico-chemical properties of soils presented in Table 1 revealed that percentage of sand, silt and clay varied from 64.6 to 66.13, 8.99 to 10.84 and 23.04 to 25.59 respectively under different treatments. The PH varied from 4.3 in T_9 (100% N(S) PK+W) where nitrogen was applied as ammonium sulfate to 5.7 in T_5 (100% NPK+L+W) where lime was applied at 2.5 tons per hectare once in three years. Organic carbon varied from 0.29 in T_3 (150% NPK + W) to 0.41% in T_8 (100% NPK+FYM+W) where FYM was applied at 10 tons per hectare every year in preceding *kharif* crop.

Water Soluble and Exchangeable Zn

Data on different fractions of Zinc with the total content are presented in Table 2. The data revealed that the water soluble and exchangeable forms of zinc were quite low being 1% in all the treatments. The highest amount of water soluble and exchangeable Zn being 0.45 and 0.71 mg/kg respectively were re-

Table 1. Physico-chemical properties of soils as affected by continuous cropping and fertilizer use. W=Weedicide, HW=Hand weeding, N(S) PK = Nitrogen fertilizer having sulfur source.

Treatments	Sand (%)	Silt (%)	Clay (%)	pH	Organic carbon (%)
T_1 (50% NPK+W)	65.44	10.78	24.78	5.2	0.31
T_2 (1000%NPK+W)	65.03	10.84	24.13	4.8	0.34
T_3 (150% NPK+W)	65.50	8.99	25.51	4.7	0.29
T_4 (100%NPK+HW)	64.24	10.28	25.38	4.8	0.35
T_5 (100% NPK+ L+W)	64.19	10.68	23.13	5.7	0.36
T_6 (100% NP+W)	64.39	10.26	25.35	5.0	0.30
T_7 (100% N+W)	64.04	10.84	23.12	4.5	0.30
T_8 (100% NPK+ FYM+W)	64.42	8.99	25.59	5.3	0.41
T_9 (100% N(S) PK+W)	65.24	9.34	24.42	4.3	0.31
T_{10} (Control)	66.13	10.83	23.04	5.2	0.30

corded in T_8 (100% NPK+FYM+W). Iyenger and Deb (1) reported negligible amount of water soluble and exchangeable Zn in soil with high soil pH. This fraction was low in soil but constituted the most readily available form of Zn for plant nutrition.

Specially Adsorbed Zn

The value of specially adsorbed Zn was recorded in T_8 (100% NPK+FYM+W) being 2.05 mg/kg and lowest in T_{10} (control) being 0.99 mg/kg. The specially adsorbed Zn fraction was marginally lower than water soluble plus exchangeable and acid soluble forms of Zn but lower than those of Mn oxide occluded, organic matter occluded, amorphous Fe oxide occluded, crystalline Fe oxide occluded and residual Zn which is in agreement with the findings of Dhane and Shukla (2).

Acid Soluble Zn

This fraction was also found very low in all the treatments and ranged from 0.61 to 1.41 mg/kg the lowest being in T_{10} (control) and highest in T_8 (100% NPK+FYM+W). This fraction was found to be lower than other Zn fraction.

Mn Oxide Occluded Zn

The Mn oxide occluded Zn varied from 1.40 to 4.8 mg/kg, being lowest in T_{10} (control and highest in T_8 (100% NPK+FYM+W). Mn oxide occluded Zn was higher as compared to water soluble, exchangeable, specially adsorbed and acid soluble forms of Zn but lower than organic matter occluded, amorphous Fe oxide occluded, crystalline Fe oxide occluded and residual forms of Zn in all the treatments.

Organic Matter Occluded Zn

This fraction of Zn ranged from 1.5 to 5.5 mg/kg. The highest value was recorded in T_8 (100% NPK+FYM+W) and lowest in T_{10} (control). The or-

Table 2. Different forms of Zn (mg/kg) in soil as influenced by continuous cropping and fertilizer use after harvest of wheat. W=Weedicide, HW=Hand weeding, N (S) PK=Nitrogen fertilizer having sulfur source.

Treatments	Water Soluble Zn	Exch Zn	Specially adsorbed Zn	Acid soluble Zn	Mn-oxide occluded Zn	Organic matter occluded Zn	Amorphous Fe-oxide occluded Zn	Crystalline Fe-occluded Zn	Residual Zn	Total Zn
T_1 (50% NPK+W)	0.20	0.42	1.40	0.93	2.51	2.51	3.22	5.20	64.61	81.00
T_2 (1000% NPK+W)	0.21	0.43	1.39	0.97	3.81	3.91	4.20	4.90	65.19	85.00
T_3 (150% NPK+W)	0.23	0.50	1.41	0.99	3.79	3.80	4.50	6.10	66.68	86.00
T_4 (100% NPK + HW)	0.19	0.21	1.37	0.87	2.67	2.81	3.20	5.30	62.38	79.00
T_5 (100% NPK +L+W)	0.04	0.09	1.05	0.70	1.59	2.00	2.50	3.50	44.53	56.00
T_6 (100% NP+W)	0.09	0.18	1.45	0.81	2.48	2.95	4.00	4.52	57.52	64.00
T_7 (100% N + W)	0.08	0.10	1.25	0.87	2.35	2.83	3.00	5.11	45.41	59.00
T_8 (100% NPK+ FYM+W)	0.45	0.71	2.05	1.41	4.80	5.50	7.20	9.40	75.48	107.0
T_9 (100% N(S)PK+W)	0.24	0.58	1.45	1.05	3.90	3.90	5.10	8.70	64.63	90.00
T_{10} (Control)	0.02	0.12	0.99	0.61	1.40	1.50	3.00	4.30	41.06	52.00

Table 3. Coefficient of correlation (*r*) between different forms of Zn in soil and different soil properties as influencd by continuous cropping and fertilizer use after harvest of wheat 1995-96.

Treatments	pH	Organic carbon	Sand	Silt	Clay
Water Soluble Zn	-0.234	0.754**	-0.048	-0.729*	0.698*
Exchangeable Zn	-0.269	0.591*	0.237	-0.755**	0.611*
Specially adsorbed Zn	-0.192	0.649*	-0.237	-0.684*	0.747**
Acid soluble Zn	-0.436	0.415	-0.033	-0.741*	0.470
Mn-oxide occluded Zn	-0.452	0.677*	-0.057	0.772**	0.620*
Organic Matter occluded Zn	-0.368	0.703*	-0.184	-0.747**	0.620*
Amorphous Fe-oxide occluded Zn	-0.239	0.690*	-0.156	-0.790**	0.693*
Crystalline Fe occluded Zn	-0.210	0.779**	-0.143	-0.862**	0.696*
Residual Zn	-0.261	0.684*	0.143	-0.698*	0.752**
Total Zn	-0.270	0.684*	0.052	-0.684*	0.699*

ganic matter occluded Zn in soils varied directly with organic carbon content of soils and soil pH. These findings are in agreement with the findings of Srivastava and Srivastava (3).

Amorphous Fe-Oxide Occluded Zn

The amorphous Fe- oxide occluded form of Zn varied from 2.50 to 7.20 mg/kg. The highest contribution of this fraction was recorded in T_8 (100% NP+FYM+W) and lowest in T_5 (100% +NPK+F+W). Mandal and Mandal (4) reported that the amount of this fraction appeared to be directly related to free Fe_2O_3 content of soil.

Crystalline Fe- Occluded Zn

The value of crystalline Fe occluded Zn varied from 3.50 to 9.40 mg/kg. The highest amount of this fraction was found in T_8 (9.40 mg/kg) and lowest in T_5 (3.50 mg/kg). The amount of this fraction also appeared to be related directly to free Fe_2O_3 content of soil as also suggested by Mandal and Mandal (4).

Residual Zn

It constitutes the major fraction of Zn in soil which is apparently associated with soil mineral. It varied from 41.06 to 75.84 mg/kg. This pool constitutes major portions of total Zn content. The highest amount of residual Zn fraction was obtained in T_8 (75.48 mg/kg) and lowest in T_{10} (41.06 mg/kg). This may be due to highest organic carbon content of soil. Amount of residual form of Zn also increased with increasing clay content of soils. Similar observation has been made by Presad and Sakal (5).

Total Zn Fraction

Total Zn content of soil ranged from 52.0 to 107.0 mg/kg in T_{10} (control) and T_8 (100% NPK+FYM+W)

Table 4. Coefficient of correlation (*r*) among different forms of Zn in soils as influenced by continuous cropping and fertilizer use After harvest of wheat 1995-96. **Significant at 1%, *Significant at 5%.

Treatments	Water soluble Zn	Exch Zn	Specially adsorbed Zn	Acid soluble Zn	Mn-oxide occluded Zn	Organic matter occluded Zn	Amorthous Fe-oxide occluded Zn	Fe-occluded Zn	Residual Zn	Total Zn
Water Soluble Zn	–									
Exch. Zn	0.924**									
Specially Adsorbed Zn	0.930**	0.805**								
Acid Soluble Zn	0.836**	0.879**	0.771**							
Mn- Oxide occluded Zn	0.898**	0.889**	0.840**	0.858**						
Org. Matter Occluded Zn	0.918**	0.862**	0.913**	0.846**	0.978**					
Amorph. Fe- Oxide Occluded Zn	0.919**	0.866**	0.953**	0.823**	0.936**	0.977**				
Crystalline Fe-Occluded Zn	0.943**	0.871**	0.927**	0.818**	0.922**	0.954**	0.973**			
Residual Zn	0.920**	0.925**	0.769**	0.763**	0.858**	0.810**	0.791**	0.825**		
Total Zn	0.978**	0.943**	0.882**	0.866**	0.903**	0.895**	0.881**	0.888**	0.957**	–

respectively. Higher amount of total Zn content was due to higher content of organic carbon an clay content. Continuous cropping and imbalance application of fertilizer reduced the content of different fraction of Zn in soil. Application of FYM along with 100% NPK considerably enhanced the content of different forms of Zn in soil. This may be due to chelating action of organic matter.

Correlation Studies Between Various Zn Fraction of Soils and Soil Properties

The relationship between different Zn fraction of soils and soil properties are presented in Table 3. Result showed negative and non-significant correlation between different forms of Zn with soil pH and percent sand content. Significant positive correlations were observed between different forms of soil Zn with clay and organic carbon contents. Similar observations have been made by Dane and Shukla (2) and Singhal and Rattan (6). Residual Zn was positively and significantly correlated with clay, which indicated bulk of residual Zn to be associated with the soil clay minerals. Strong correlation existed between clay and Mn-oxide occluded clay and Fe-oxide occluded Zn which indicated that matrix of free oxides capable of occluding zinc, resides predominantly in the clay fraction as also reported by Singhal and Rattan (6).

Correlation Among Different Zn Fractions of Soils

The different forms of Zn present in soils significantly and positively correlated among themselves (Table 4) thereby indicating existence of dynamic equilibrium among different pools of soil Zn (5, 6). Dynamic equilibrium among different pools of soil Zn indicated that the depletion in the concentration of readily available forms of Zn is replenished by the other pool of soil zinc (7—9).

References

1. Iyenger B. R. V. and D. L. Deb. 1977. Contribution of soil zinc fraction to plant uptake and fate of zinc application to the soil. *J. Ind. Soc. Soil Sci.* 25 : 863.
2. Dane S. S. and L. M. Shukla. 1995. Distribution of different forms of zinc in benchmark and other established soil series of Maharastra. *J. Ind. Soc. Soil Sci.* 43 : 594.
3. Srivastava A. K. and O. P. Srivastava. 1992. Fractions and availability of applied Zn in salt affected soil amended with Gypsum and pyrites *J. Ind. Soc. Soil Sci.* 40 : 890.
4. Mandal L. N. and B. Mandal. 1986. Zinc fraction in soils in relation to Zn nutrition of low land rice. *Soil Sci.* 142 : 141.
5. Prasad R. and R. Sakal. 1988. Effect of soil properties on different chemical pools of Zn in calcareous soils. *J. Ind. Soc. Soil Sci.* 36 : 246.
6. Singhal S. K. and R. K. Rattan. 1995. Soil zinc fractions and their availability in some inceptisols and entisols. *J. Ind. Soc. Soil Sci.* 43 : 80.
7. Prasad R. and L. M. Shukla. 1996. Forms of zinc and their relationship with soil properties. *J. Ind. Soc. Soil Sci.* 44 : 516.
8. Prasad B., I. Sarangtham and K. C. Choudhary. 1988. Transformation and availability of applied Zn to Maize in calcareous soil. *J. Ind. Soc. Soil Sci.* 43 : 84.
9. Mete P. K., B. Mandal and L. N. Mandal. 1996. Distribution of zinc fraction in red and lateritic soils of WB. *J. Ind. Soc. Soil Sci.* 44 : 156.