

Zinc Transformation in Soil under Submerged Condition

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SUMMARY

Transformation of Zinc in soil submerged condition leads to various chemical forms, in soil solution as ionic or organically complexed species, on exchange sites of reactive soil components, complexed with organic matter, occluded in oxides and hydroxides of Al, Fe and Mn, entrapped in primary and secondary minerals. Zinc in soluble organic complexes and exchange positions are of major importance in maintain of zinc level sufficient for wetland rice. When a soil is submerged, a number of chemical and electrochemical changes occur, such as adjustment of soil pH towards neutrality, increase in partial pressure of CO₂ and decrease in redox potential. These forms are in a state of dynamic equilibrium. The amount and rate of transformation of these forms of zinc determine the size of the labile zinc pool.

INTRODUCTION

During the last few decades, agricultural production has increased due to use of high yielding varieties and enhanced consumption of chemical fertilizers. Imbalanced use of chemical fertilizers by farmers has deteriorated soil health and declined soil organic carbon content. This has caused deficiencies in nutrients and micronutrient like Zn resulting in major problem in achieving higher yield targets of rice. It is essential to adopt a strategy of using chemical fertilizers with organic manures. Zinc is involved in many enzymes activities, but it is not known whether it acts as functional, structural or regulatory co-factor. However, zinc is required for synthesis of tryptophan and production of growth hormones (auxins) such as indole acetic acid. It is a constituent of enzymes like carbonic anhydrase, superoxide dismutase, and alcoholic dehydrogenase and also involved in the protein and nucleic acid metabolism of plants. Zinc exists in five distinct pools in soils. These pools differ in strength (or reversibility) and therefore in their susceptibility to plant uptake, leaching and extractability. Zinc in soluble organic complexes and exchange positions are of major importance in maintaining of zinc level sufficient for wetland rice (Murthy, 1982). Widespread occurrence of Zn deficiency in paddy soils suggests that both native and applied Zn react with the inorganic and organic phases in the soil and thereby affect its availability. A proper understanding of the fractions which control the distribution of Zn between active soil constituents and soil solution is fundamental to understanding of the chemistry of zinc in soil (Viets, 1962). Water soluble plus exchangeable and organically complexed forms are considered to be available; amorphous sesquioxide bound form is potentially available and crystalline sesquioxide bound and residual zinc forms are unavailable to plants (Mandal et al., 1993). The availability of zinc to plants has been observed to vary with different zinc fractions. About 5 per cent or less of total zinc present in soil is available to plants at any given time. The form in which zinc is present in soil plays a crucial role in determining its availability to plants. Distribution of forms of zinc in soils depends on the chemical and physical properties. The availability of soil zinc to plants is governed by different fractions of soil zinc. Knowledge on distribution of zinc fractions in soils and various soil properties influencing its availability might prove to be the best approach for obtaining reliable information about the need of zinc.

Fractionation of zinc in soils

Zinc in soils was fractionated into different forms designated as water soluble + exchangeable (WSEX-Zn), organically complexed (OM- Zn), crystalline sesquioxide bound (CRYOX-Zn), amorphous sesquioxide bound (AMOX-Zn), manganese oxide bound (MnOX- Zn) and Residual (RES) zinc. Each fraction is operationally defined as given below Murthy (1982) modified by Mandal & Mandal (1986).

Extractant	Step	Fraction	Conditions Solution Soil (g): Solution (ml)
1M (NH ₄)OAc (pH 7.0)	1	Water soluble + Exchangeable (WSEX-Zn)	5: 20; shake for 1 hour

0.05 M Cu(OAc) ₂	2	Organically complexed (OM-Zn)	5: 20; shake for 1 hour
0.3 M Sodium citrate + 1.0 M NaHCO ₃ + 1 g Na ₂ S ₂ O ₄ [Citrate-Bicarbonate-Dithionite (CBD)]	3	Crystalline sesquioxide bound (CRYOX-Zn)	Boiling water bath, 10 min, stir occasionally, keep on water bath (70 – 80°C), 15 min, stir occasionally
0.2 M (NH ₄) ₂ C ₂ O ₄ .H ₂ O + 0.2 M H ₂ C ₂ O ₄ (pH 3.0)	4	Amorphous sesquioxide bound (AMOX-Zn)	5: 20 shake 1 hour
0.1 M NH ₂ OH.HCl (pH 2.0)	5	Manganese oxide bound (MnOX- Zn)	Shake 30min
HCl+ HNO ₃ conc	6	Residual (RES) zinc	1: 08 Aqua regia
Sum of the extractable amounts	7	Total	

The extractions were taken in 50 ml polypropylene centrifuge tubes with suitable weight of soil. Between each successive extraction, the supernatant was obtained by centrifuging for 15 min (3000 rpm) and filtering. The concentration of zinc in the centrifugate was determined by Atomic Absorption Spectrophotometer (Page *et al.*, 1982).

Total zinc in soils

Total zinc was determined by digesting the soil samples with hydrofluoric acid in closed polypropylene bottles. 100 mg of soil sample was transferred into a 250 ml polypropylene bottle, 2 ml of aquaregia was added to disperse the sample. Later, exactly 10 ml of hydrofluoric acid was added and the contents were shaken to dissolve the sample for a period of 2 to 8 hrs. The residue present after the treatment was dissolved using saturated solution of boric acid and subsequently used for the determination of total Zn by atomic absorption spectrophotometry (Page *et al.*, 1982).

CONCLUSION

Application of recommended dose of NPK (100:50:50 kg ha⁻¹) + FYM (10 t ha⁻¹) + ZnSO₄ + 5 kg ha⁻¹ Borax recorded significantly higher water soluble and exchangeable, organically complexed, amorphous and crystalline sesquioxide bound, manganese oxide bound and residual zinc. Among the fraction, the residual zinc recorded highest zinc fraction and water soluble zinc recorded lowest zinc fraction.

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