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Distribution of zinc pools as influenced by long-term application of fertilizers and manure in a Vertisol

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Abstract
The present investigation was carried out a permanent site at the Research farm of the Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur. The study was aimed to find out the effect of continuous application of inorganic fertilizers and organic manure on the depth wise distribution of Zn fractions under soybean-wheat cropping sequence in a Vertisol at Jabalpur, Madhya Pradesh during 2016–17. The experiment consists of ten treatments *i.e.* T_1 50% NPK, T_2 100% NPK, T_3 150% NPK, T_4 100% NPK + Hand weeding, T_5 100% NPK + Zn ($ZnSO_4$), T_6 100% NP, T_7 100% N, T_8 100% NPK+FYM, T_9 100% NPK–S (Sulphur free) and T_{10} control with four replications in a randomized block design. Results revealed that the highest content of DTPA-Zn and its fractions (water soluble-Zn, exchangeable-Zn, complexed-Zn, organically bound-Zn, occluded-Zn and residual-Zn) were recorded in the treatment receiving 100%NPK + Zn, followed by 100% NPK +FYM; while the lowest content of DTPA-Zn and thier fractions were noted in treatment where no fertilizer and organic manure was applied since inception of experiment. The available Zn and various Zn fractions were found to be higher in 0–20 cm soil depth which decreased with increasing soil depth in all the treatments. Zinc content in various fractions varied in the order of water soluble <exchangeable-Zn <complexed-Zn <organically bound-Zn <occluded-Zn <residual-Zn.

Keywords: Zinc fractions, DTPA-extractable Zn, long-term experiment, soybean–wheat sequence.

Introduction
Micronutrient deficiencies, particularly zinc (Zn) deficiency, infield crops are widespread all over the world because of increased Zn demands of intensive cropping systems and adoption of high-yielding cultivars with relatively greater Zn demand. Other reasons for the increase in Zn-deficient areas are enhanced production of crops on soils that contain low levels of Zn, increased use of high analysis fertilisers containing low amounts of Zn, decreased use of animal manures, composts, and crop residues, and involvement of natural and anthropogenic factors that limit adequate plant nutrient availability and create nutrient imbalances [1]. Although the amount of zinc needed for crop growth is far less than that of macronutrients, Zn deficiency in soil has been reported widely from different parts of the world [2]. It is known that much of the Zn remain in soils bound by oxides of iron. On submergence, these oxides undergo reduction due to anaerobiosis, to the lower valiant forms which are more soluble. The bound Zn is therefore released and becomes available to the crop plants [3]. Information regarding the distribution of different pools of Zn and their changes in soil which are very pertinent to Zn nutrition and soil nutrient availability are very limited in soils of M.P. Therefore, considering the above facts an investigation under taken on a Long Term Fertilizer Experimental trial to evaluate the impact of input management on sustainable soil fertility and subsequently crop productivity. The problem is more acute in India, where enhancing productivity through intensive cropping has occurred in past four decades [4]. It has been observed that soil various Zn pools: water soluble, easily exchangeable, adsorbed, chelated, or complexed, associated with secondary minerals, and held in primary minerals [5]. Amongst the essential plant nutrient zinc is an essential element in plant growth and metabolism and exists in soil in different forms such as primary and secondary minerals, insoluble organic and inorganic precipitates, soluble organic complexes and exchangeable and adsorbed forms. Zinc in soluble organic complexes and exchange positions are of major importance in maintaining of Zn fertility levels sufficient for crop requirement [6]. On the contrary widespread occurrence of Zn deficiency in soils suggests that both native and applied Zn react with

inorganic and organic phases in the soil system and thereby affect its availability. When Zn is applied to the soil from external sources to correct its deficiency it undergoes transformation to various chemical forms, the nature and magnitude of which, however may differ in different soils depending upon their properties and associated environmental conditions [7].

Materials and Methods

The research study involved diverse works to study changes in soil quality, crop productivity and sustainability in Soybean–Wheat cropping system. The soil under experiment represent a medium deep black soil classified as very fine, belonging to Kheri series of fine *montmorillonitic hyperthermic* family of Typic *Haplustert.* At the initiation of this experiment in 1972

Soil Analysis

The soil samples were collected with the help of tube auger from the each plot at plough layer (20 cm) from the long-term fertilizer experiment on a permanent site at the Experimental Research Station of J.N. Krishi Vishwa Vidyalaya, Department of Soil Science and Agricultural Chemistry, Jabalpur (M.P.).

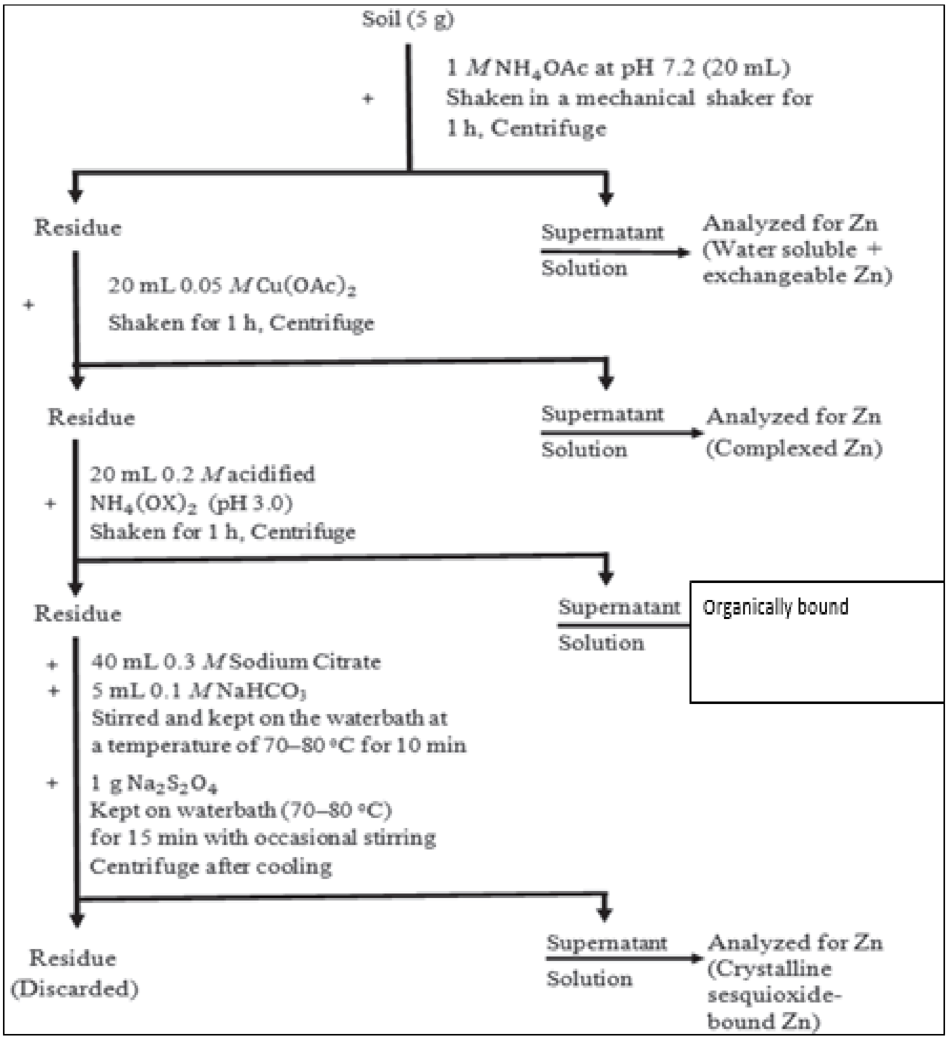
Composite representative soil samples were obtained from these samples for each plot. These soil samples were cleaned, air-dried, crushed by wooden pestle and mortar passed through 2 mm stainless steel sieve and stored in polythene bags at room temperature until analysis. These soil samples were used for analysis.

Determination of available and Zinc Fractions in Soil

The available Zn was estimated by Lindsay and Norvell's procedure (1969) using an extractant consisting of 0.005M Diethylene triamine penta-acetic acid (DTPA), 0.1M C_aCl_2 and 0.1M triethanol-amine adjusted to pH 7.3

The soils were air dried ground and passed through a 2 mm sieve. A portion of the sample was stored for analysis of different physicochemical properties and Zn fractions of the soils. The different Zn fractions were analyzed with the standard procedure by the procedure of Murthy (1982). The flow chart of the scheme of fractionation is shown below.

1. Water soluble and exchangeable zinc fraction (WSEX-Zn):
2. Complexed zinc fraction (COMP-Zn):
3. Amorphous sesquioxide bound zinc:
4. Crystalline sesquioxide bound zinc (CBD):
5. Residual zinc fraction (RES-Zn)



Results and Discussions

Distribution pattern of Available and Zinc fractions in soil

Available Zn content in soil indicated that there was higher accumulation of Zn noticed with 100NPK +FYM in spite of discontinued Zn application was found to be high. In this regarded a critical inspection of the soil Zn status further suggested that the inclusion of FYM alone with 100% NPK contributed significantly to a remarkable extent leading to its buildup. (Dwivedi and Dwivedi 2015). The experiment to study the influence of fertilizer and manure on various fractions of zinc namely water soluble-Zn, Exchangeable zinc, complexed zinc, organically bound, occluded, residual and total content in soil are presented in tables. The DTPA-extractable Zn concentration of NPK+Zn was significantly higher in surface (0–15 cm) and sub surface (15–30cm) soil for both the pre and post sample. Annual application of organic manure FYM resulted in higher DTPA soil extractable Zn, which may be due to mineralisation of organically bound Zn in FYM and formation of organic chelates of higher stability (8). The DTPA-Zn concentration of the subsurface soil was lower than that of the surface soil in all treatments, which is in agreement with findings of [8-9] for a long-term. This fraction ranged from 0.043 to 0.119 mg kg-1. The both Zn fraction were positively and significantly correlated with OC content of the soil suggesting that organic matter provides more exchange sites for adsorption of Zn [10]. High buffering capacity of these soils resulted in low amount of water soluble plus exchangeable Zn [11] content. Similar results were also reported by many workers [12]. Complexed Zn fraction ranged from 0.186 to 0.369 mg kg-1.The present results are in agreement with the findings of Narwal *et al*.,2010, who also observed that complexed Zn fraction in most of the soils was marginally higher than the water soluble plus exchangeable Zn, comprising about 0.3 to 6.0 per cent of total Zn. The wider variation in its content in different soils could be mainly due to the genesis of soils from different parent materials [13]. The COMP-Zn was significantly and positively correlated with OC of the soil suggesting that organic matter provides more exchange sites for adsorption of Zn. Similar results were also observed by [14]. The results are in conformity with that of [15] Organically fraction ranged from 0.50 to 1.28 mg kg^{-1} this finding indicated that use of organic manure may play a significant role in Zn availability in soil system specially as organically bound fraction [16] Occluded Zn fraction ranged from 0.52 to 1.43 mg kg-1. The higher content of organically bound Zn than occluded Zn in soils could be attributed to the greater ability of organically bound to adsorb Zn because of their high specific surface area [17-19]. Higher amount of amorphous Fe oxides compared to crystalline Fe oxide in acidic environment. Residual Zn was the dominant fraction among all the Zn fractions studied and is in agreement with the findings of [7].This fraction ranged from 27.72 to 76.12 mg kg^{-1}.This fraction ranged from 29.11 79.58 mg kg-1.The variation in total Zn might be attributed to the fact that soils have treated with varying does of fertilizer as well as organic manure consequently affect the availability of zinc fraction on soil thereby facilitating the predominance of residual fraction content in soil system (Krishna [20].

Table 1: Effect of nutrient management on distribution of different forms of Zn at 0-15cm depth (mg kg^{-1})

Treatment	Available Zn		Water Soluble		Exchangeable		Comlexed		Organically bound		Occluded		Residual-Zn		Total-Zn	
Depth (cm)	**0-15 cm**	**15-30 cm**	**0-15**	**15-30**	**0-15**	**15-30**	**0-15**	**15-30**	**0-15**	**15-30**	**0-15**	**15-30**	**0-15**	**15-30**	**0-15**	**15-30**
50% NPK	0.673	0.508	0.067	0.051	0.158	0.143	0.221	0.200	0.73	0.56	0.81	0.61	53.11	47.53	55.09	49.09
100% NPK	0.825	0.558	0.083	0.056	0.165	0.150	0.230	0.209	0.91	0.61	0.99	0.67	62.88	50.74	65.26	52.43
150% NPK	0.915	0.808	0.092	0.081	0.178	0.162	0.249	0.228	1.02	0.89	1.10	0.97	68.65	66.76	71.29	69.09
100%NPK+HW	0.650	0.602	0.065	0.061	0.156	0.141	0.219	0.198	1.01	0.96	0.78	0.75	53.67	51.01	55.89	53.52
100% NPK+Zn	1.188	1.130	0.119	0.113	0.264	0.248	0.369	0.348	1.28	1.24	1.43	1.36	76.12	72.43	79.58	75.74
100% NP	0.805	0.543	0.081	0.054	0.146	0.131	0.204	0.183	0.87	0.60	0.97	0.65	61.60	49.77	63.87	51.39
100% N	0.480	0.425	0.048	0.043	0.136	0.121	0.190	0.169	0.55	0.47	0.58	0.51	50.77	49.24	52.27	50.55
100% NPK+FYM	1.085	1.065	0.109	0.107	0.240	0.221	0.335	0.312	1.19	1.17	1.30	1.28	69.55	68.27	72.73	71.35
100% NPK-S	0.585	0.530	0.059	0.053	0.152	0.138	0.213	0.192	0.65	0.58	0.70	0.64	51.50	48.97	53.27	50.57
Con Control	0.320	0.280	0.043	0.028	0.133	0.118	0.186	0.165	0.50	0.31	0.52	0.34	49.72	48.95	51.11	49.90
SEm (±)	0.043	0.041	0.004	0.004	0.010	0.010	0.015	0.014	0.053	0.046	0.052	0.050	2.77	2.65	2.82	2.75
CD (5%)	0.125	0.120	0.013	0.012	0.030	0.029	0.042	0.041	0.153	0.132	0.150	0.144	8.04	7.70	8.18	7.99

References

1. Fageria NK, Baligar VC, Clark RB. Micronutrients in crop production. Advances in Agronomy. 2002; 77:185-250.
2. Welch RM, Allaway WH, House WA, Kubota J. Geographic distribution of trace element problems, In ‘Micronutrients in agriculture’.2nd edn (Eds JJ Mortvedt, LM Shuman, RM Welch) pp. 31-57.
3. Obrador A, Alvares JM, Lopez-Valdivia LM, Gonzalez D, Movillo J, Rico MI *et al* Relationship of soil properties with Mn and Zn distribution in acidic soils and their uptake by a barley crop. Geoderma. 2007;137:432-443
4. Suman j, Dwivedi BS, Dwivedi AK, Pandey SK. Distribution of zinc pools as influenced by long-term application of fertilizers and manure in a Vertisol. Green farming. 2017;8(5):1105-1110
5. Viets FG Jr. Chemistry and availability of micronutrients in soils. Journal of Agricultural Food Chemistry. 1962; 10:174-179.
6. Murthy ASP. Zinc fractions in wetland rice soils and their availability to rice. Soil Science. 1982; 133:150-154.
7. Mishra P, Singh R, Srivastava PC, Bali R. Effect of continuous cropping and fertilization on zinc fractions and their contribution to plant uptake under rice-wheat system. J. Indian Soc. Soil Sci. 2009; 57:167-171
8. Rathore GS, Khamparia RS, Gupta GP, Sinha SB. Availability of micronutrients in some alluvial soil and their effect on wheat. J. Indian Soc. Soil Sci. 1980; 28:248-250.
9. Verma S, Subehia SK. Zinc availability in an acid Alfisol as influenced by long-term cropping in a wet temperate zone of western Himalayas. Agropedology. 2005; 15:95-99.
10. Zhang YG, Zhang YY, Cai JP, Zhu P, Gao HJ, Jiang Y *et al.* Variation in available micronutrients in black soil after 30-year fertilization treatment Plant Soil Environ. 2014; 60(9):387-393.
11. Deb JK, Sehgal JL. Characterization and classification of some alluvium derived paddy and associated non-paddy soils of Assam. Agropedology. 1997; 7:22-31
12. Raja EM, Iyeagar BRV. Chemical pools of zinc in some soils as influenced by sources of applied zinc. J. Indian Soc. Soil Sci. 1986; 34:97-105.
13. Yaduvanshi HS, Sharma KL, Singh K, Verma TS. Distribution of chemical forms of zinc in soils of varying

orders under different climatic zones. J. Indian Soc. Soil Sci. 1988; 36:427-432.
14. Prasad R, Sakal R. Effect of soil properties on different chemical pools of zinc in calcareous soils. J. Indian Soc. Soil Sci. 1988; 36:246-251.
15. Yashodha P, Konwar BB. Contribution of zinc fraction to available Zn extracted by some chemical methods from rice growing soils of North Western Himalaya. Plant and Soil. 1990; 126:149-153.
16. El-Fouly MM, Fawzi AFA, Abou El-Nour EAA, Zeidan MS, Firgany AH. Impact of long-term intensive cropping under continuous tillage and unbalanced use of fertilizers on soil nutrient contents in a small holding village. African Journal of Agricultural Research. 2015; 10(53):4850-4857
17. Wijebandara DMDI, Dasog GS, Patil PL, Hebbar M. Zinc fractions and their relationships with soil properties in paddy growing soils of northern dry and hill zones of Karnataka. J. Indian Soc. Soil Sci. 2011; 59:141-147.
18. Verma G, Sharma RP, Sharma SP, Subehia SK, Shambhavi S. Changes in soil fertility status of maize-wheat system due to long-term use of chemical fertilizers and amendments in an alfisol. Plant Soil Environ. 2012; 58(12):529-533.
19. Behera SK, Singh D, Dwivedi BS, Singh S, Kumar K, Rana DS *et al* Distribution of fractions of zinc and their contribution towards availability and plant uptake of zinc under long-term maize (Zea mays L.) - wheat (Triticum aestivum L.) cropping on an inceptisol. Australian Journal of Soil Research. 2008; 46:83-89
20. Krishnakumar AK, Patty SN. Nutrition of Hevea. In Natural Rubber: Biology, Cultivation and Technology (M.R. Sethuraj and N.M. Mathew, Eds.) Elsevier, Amsterdam, 1992.