Journal of Applied and Natural Science 8 (1): 329 - 332 (2016)

JANS

Zinc dynamics in an Alfisol as influenced by levels of farm yard manure

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Received: June 28, 2015; Revised received: November 19, 2015; Accepted: March 2, 2016

Abstract: Field experiments were conducted on sandy loam soil at Shimoga, Karnataka, India to study the influence of FYM application on dynamics of zinc in an Alfisol under fingermillet (*Eleusine coracana* L.) crop. Three levels of FYM viz., 7.5, 15.0 and 22.5 t/ha with and without recommended dose of fertilizer (RDF) were evaluated for the purpose. Changes in available (DTPA extractable) and different fractions of Zn in soil were monitored. Application of FYM at all levels, with or without fertilizers, caused significant ($p<0.05$) increase in DTPA-Zn, the effect being more pronounced at higher levels. Maximum DTPA- zinc (0.97 mg/kg) in soil was observed in the treatment RDF+FYM@ 22.5 t/ha. Increase in level of FYM application increased the water soluble, sorbed, easily reducible manganese bound, carbonate bound and organic bound fractions of Zn significantly ($p<0.05$), but decreased residual fractions in soil compared to that of RDF and absolute control treatments. All the fractions except residual one had positive and significant correlation with each other indicating the existence of a dynamic equilibrium among them. DTPA-Zn was positively and significantly ($p<0.01$) correlated with soil OC, WS, SORB, ERMn, CA, OM and Fe and Alox fractions (r= 0.683,0.603,0.683,0.702,0.777,0.678 and 0.476 respectively) in soil. The treatment receiving RDF+FYM @ 22.5 t/ha excelled over others with respect to grain and straw yield (3.028 t/ha and 1.890 t/ha respectively) of fingermillet. Thus, keeping in view the availability of Zn in soil and yield of fingermillet, FYM @22.5 t/ha supplemented with RDF was found to be the superior one.

Keywords : Crop yield, Forms of Zn, Labile pool, Organics, Transformations

INTRODUCTION

Soil organic matter (SOM) can exert profound influence on soil properties, ecosystem functioning and magnitude of various obligatory ecosystem processes, and thus forms an important component of the ecosystem. Beneficial effects include SOM acting as a source of major plant nutrients, a promoter of favourable soil physical conditions, soil biota population, and nutrient cycling processes (Goh, 2004). Organic matter, besides supplying nutrients to growing plants, react with native reserves of micronutrient elements, thus modifying their availability.

Zinc in soil can exist in different forms viz., water soluble, sorbed, easily reducible, manganese bound, carbonate bound, organic bound, iron and aluminium oxides bound and residual forms, which are varying in solubility and mobility. The distribution and relative abundance of these fractions of zinc in soil could be used to predict the fate of plant available Zn . Addition of organic matter might alter or modify the relative abundance of these fractions and their contribution to the available pool of Zn in soils. Soluble organic matter-Zn complexes in soil solution assist in bringing Zn to plant roots thus enhancing its availability, whereas, organic ligands released during organic matter decomposition may also bind Zn too tightly to decrease plant availability (Shuman, 2005).

Consequently, the present research study was conducted with a prime objective to investigate the impact of levels of organic matter,viz. FYM on the distribution of zinc fractions, and their contribution towards the available pool in soils. This study will provide insights into the dynamics of Zn in soil as influenced by different management practices and thus may further help in selecting the best practice out of them.

MATERIALS AND METHODS

Experimental sites: Field experiments were conducted during kharif season of 2012-13 and 2013-14 on sandy loam soil (Typic Haplustalf) in the research farm of College of Agriculture, Shimoga, Karnataka, India (14º01' N, 75º41' E, altitude 650m above the m.s.l). The soil was having pH 5.94, EC 0.02 dS/m, oxidizable organic carbon 1.04 g/kg, available N 330.2 kg/ha, available P_2O_5 60.48 kg/ha, available K_2O 154.55 kg/ha and available Zn 0.60 mg/kg. FYM used in the experiments was having pH 7.43, 10.12 % oxidizable organic carbon and 75.17 mg/kg zinc.

Experimental design, treatments and crop management: The treatments comprised of absolute control, recommended dose of fertilizer (RDF), combinations

ISSN : 0974-9411 (Print), 2231-5209 (Online)

of three levels of FYM (7.5, 15, 22.5 t/ha) applied both without and with RDF (50:40:25 kg $N:P_2O_5:K_2O$ / ha).Total eight of these treatments, each replicated thrice, were laid out in randomized block design, using fingermillet (*Eleusine coracana* L.) as test crop under rainfed condition. Seedlings of fingermillet (var. GPU 28) were transplanted in each plot with a spacing of 30 cm between the rows and 10 cm between the plants. FYM, where required, were added at respective levels about one month before transplanting the crop to the main field. 50 percent of the recommended dose of nitrogen and full dose of phosphate and potash were applied as basal in the form of Urea, Diammonium phosphate (DAP) and Muriate of potash (MOP) respectively. The remaining 50 per cent N was applied as top dressing after 6 weeks of planting. Inter-cultivation operations, as and when required, were taken up during the entire crop growth period.

Data collection and analysis: Composite surface (0-15cm) soil samples were collected from the site before the experiment and analysed for their initial physico-chemical properties. Soil samples were also collected from each plots at 30 DAT, 60 DAT and harvest stage of crop for analysis of several parameters.The collected soil samples were air-dried and passed through 2 -mm sieve prior to analysis. The pH of soil sample was determined in 1:2.5 (soil:water) suspension whereas that of FYM in 1:10 (FYM:water) suspension using digital pH meter. Organic carbon (OC) content both in soil and FYM were determined by wet oxidation method (Walkley and Black, 1934). Zn concentration in FYM was analyzed by digesting the sample using di -acid mixture (HNO3: HClO4 :: 10:4) followed by estimation in AAS after suitable dilution. Available Zn in soil was determined by atomic absorption spectrophotometer (AAS) after extracting soil sample with DTPA (diethylene triamine penta acetic acid) extractant (Lindsay and Norvell,1978). Various pools of Zn in initial and harvest soil samples were determined using different extractants according to scheme described by Ma and Uren (1995), followed by estimation of Zn content by AAS. The crop was harvested at maturity and grain and straw yields were recorded.

Data were statistically analyzed (SPSS version 16.0) and least significant difference (LSD) at 5% probability level was computed to compare the treatment means. They were also subjected to analysis of correlation through the requisite statistical computations to predict the relationship between the different parameters.

RESULTS AND DISCUSSION

Effect of FYM levels on soil reaction (pH) and soil organic carbon status: In the present study, application of increasing level of FYM (7.5 to 22.5 t/ha) with or without RDF did not influence the soil pH and OC status in soil significantly at 30 days after planting of fingermillet. However, significant effect ($p<0.05$) was found at 60 days after planting and at harvest stages of the this crop. In general, increase in the level of FYM was found to gradually decrease the soil pH and increase the OC content in soil. Similarly, Karaca (2004) reported from a soil incubation study that the soil pH decreased while content of OC increased significantly ($p<0.05$) with increasing amount of tobacco dust or mushroom compost addition.

Effect of FYM levels on available zinc status in soil: Available (DTPA extractable) Zn in soil, in the present study,was found to increase with increase in FYM levels, with or without fertilizer compared to that of absolute control and treatment receiving only RDF at all growth stages of fingermillet (Figure 2). FYM applied @ 22.5 t/ha along with or without fertilizers significantly ($p<0.05$) increased DTPA-Zn in soil over the corresponding treatments which received FYM @ 7.5 t/ha with or without fertilizers. However, maximum DTPA-extractable zinc (0.97 mg/kg) in soil was observed in the treatment that received RDF+FYM@ 22.5 t/ha. An increase in the availability of DTPA-Zn due to application of FYM may be attributed due to addition of zinc to the soil through FYM and by che-

Table 1. Effect of FYM levels with or without fertilizer on zinc fractions in soil at harvest stage of fingermillet (data are mean of 2 experiments).

Treatments	Zn Fractions (mg/Kg)							
	WS	SORB	ERMn	CA	OM	Fe & AL-ox	RES	Total
Abs. Control	0.28 (0.09)	1.17 (0.39)	0.84 (0.28)	0.39 (0.13)	1.05 (0.35)	2.76 (0.91)	296.20 (97.86)	302.69
Only RDF	0.32 (0.11)	1.03 (0.34)	0.84 (0.28)	0.44 (0.15)	1.00 (0.33)	3.00 (0.99)	295.53 (97.81)	302.16
FYM_1	0.40 (0.15)	1.63 (0.54)	1.01 (0.33)	0.43 (0.14)	1.18 (0.39)	3.45 (1.14)	294.84 (97.33)	302.92
FYM_2	0.44 (0.15)	1.84 (0.61)	1.28 (0.42)	0.49 (0.16)	1.33 (0.44)	3.55 (1.17)	294.33 (97.06)	303.26
FYM_3	0.50 (0.16)	2.03 (0.67)	1.35 (0.45)	0.61 (0.20)	1.38 (0.45)	3.72 (1.23)	293.73 (96.84)	303.31
RDF +FYM_1	0.47 (0.16)	2.02 (0.67)	1.32 (0.44)	0.51 (0.17)	1.43 (0.47)	3.22 (1.07)	293.29 (97.03)	302.26
RDF +FYM_2	0.50 (0.17)	2.09 (0.69)	1.63 (0.54)	0.58 (0.19)	1.51 (0.50)	3.21 (1.06)	292.38 (96.85)	301.90
RDF +FYM_3	0.62 (0.21)	2.47 (0.82)	1.70 (0.56)	0.60 (0.20)	1.77 (0.59)	3.49 (1.16)	291.16 (96.47)	301.82
SEM±	0.06	0.29	0.20	0.03	0.11	0.39	17.38	17.61
LSD at 5%	0.19	0.87	0.59	0.09	0.34	NS	NS	NS

(FYM_1, FYM_2, FYM_3 represent 3 levels of FYM applied viz. 7.5, 15 and 22.5 t/ha respectively; Figures in parenthesis indicate percent distribution of Zn-fractions; WS = Water soluble; SORB = Sorbed; ERMn = Easily reducible Manganese bound; CA = Carbonate bound; OM = Organic bound; Fe&Alox = Fe and Al oxides bound; RES = Residual; NS = Non significant).

Table 2. Correlation coefficients (r) between organic carbon, available (DTPA-extractable) zinc and various zinc fractions in soil.

	OC	DTPA-Zn	WS	SORB	ERMn	CA	OM	Fe & Alox	RES
OC	1								
DTPA-Zn	0.683**	1							
WS	0.683**	0.603**	1						
SORB	0.541**	0.683**	0.601**	1					
ERMn	0.714**	0.702**	0.451*	0.577*	1				
CA	0.658**	0.777*	0.564**	0.634**	0.572**	1			
OM	0.838**	0.678**	0.765**	0.654**	0.771**	0.600**	1		
Fe & Alox	0.532**	0.476*	0.452*	0.270	0.459*	0.427*	0.364	1	
RES	-0.051	-0.299	0.091	-0.162	-0.145	-0.292	0.059	-0.111	1

* Significant at 5% ; ** Significant at 1%

Table 3. Effect of FYM levels with or without fertilizer on yield of fingermillet (*Eleusine coracana* L.).

Treatments	Grain yield (t/ha)		Straw yield (t/ha)	
	2012 - 13	2013-14	2012 - 13	2013-14
Absolute control	1.814	1.921	0.971	1.151
Only RDF	2.596	2.821	1.616	1.633
FYM @ 15 t/ha	2.326	2.522	1.359	1.506
RDF+FYM @ 7.5 t/ha	2.601	2.878	1.709	1.773
RDF+FYM @ 15 t/ha	2.742	2.971	1.735	1.812
RDF+FYM @ 22.5 t/ha	2.909	3.028	1.811	1.890
SEM±	0.188	0.196	0.086	0.079
LSD at 5 %	0.570	0.596	0.262	0.239

lating action of organic compounds (organic ligands like acetate, citrate etc.) released during organic matter decomposition which might have prevented the zinc from precipitation and fixation in soil by forming soluble metal-organic complexes. This is indirectly supported by a positive and significant correlation ($r=0.683, p<0.01$) recorded between OC and DTPA-Zn in soil. Similar findings were corroborated by Karaca (2004) who found that DTPA-extractable Zn in soil increased with increasing rates of different organic wastes amendments viz. mushroom compost and tobacco dust. There was significant increase in DTPA-Zn in both clay loam and sandy loam soils, when treated with vermicompost alone or supplemented with NPK, over control and only NPK treatments (Manivannan *et al*., 2009). Results of the study conducted by Dhaliwal *et al*. (2013) reported that incorporation of FYM, Poultry manure and biogas slurry in soil before rice transplantation resulted in significantly higher content of DTPA-Zn in soil.

Effect of FYM levels on zinc fractions in soil: Complexation of metals by organic ligands (viz. acetate, citrate etc.) released during organic matter decomposition can play an important role in controlling metal solubility (Naidu and Harter, 1998)In the present study, water soluble (WS) Zn fraction in soil increased with increase in the level of FYM application with or without RDF. Further, WS-Zn in soil was found to be very low, constituting about 0.09 to 0.21 % of the total Zn present in soil (Table 1). Different levels of FYM application increased the sorbed (SORB), easily reducible manganese bound (ERMn) and carbonate bound (CA) zinc in soil over that of control. But, significant ($p<0.05$) increase was found only when increase in the level of FYM application was accompanied with RDF. The contribution of organic bound (OM) Zn towards the total Zn in soil ranged from 0.33-0.59 % , in the various treatments. All levels of applied FYM in combination with RDF, significantly ($p<0.05$) increased OM-zinc over control. Increasing level of FYM application increased the Fe and Al oxide bound zinc in soil,however the increase was not significant. Residual zinc showed a non significant decrease with increase in the level of FYM with or without RDF. However, the residual Zn showed maximum contribution (96.47-97.86%) towards the total Zn status in soil. This complies the reports of Ma and Uren (1995) who found that concentration of residual Zn was predominantly high in all the experimented soils.

DTPA-Zn was also positively and significantly ($p<0.01$) correlated with soil OC, WS, SORB, ERMn, CA, OM and Fe and Alox fractions in soil (Table 2). However, residual Zn showed negative correlation with both OC ($r= -0.051$) and DTPA-Zn ($r= -0.299$) in harvest soil.

All zinc fractions (WS, SORB, ERMn, CA and OM) except residual and total zinc were found to be positively and significantly correlated with each other (Table 2). Positive and significant correlation between water soluble plus exchangeable zinc and OC in soil of different sites in various acid soil series of India has been reported by Behera and Shukla (2013).

Effect of FYM levels on grain and straw yield of fingermillet: An increase in grain and straw yield of fingermillet,in the present study, with increase in the level of FYM may be due to the increased supply of nutrients and improvement in physical condition of soil as indicated by increase in OC status due to addition of FYM (Fig. 1). The magnitude of increase

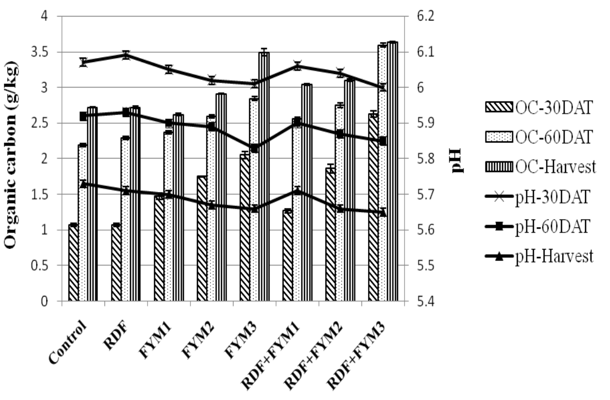

Fig. 1. *Effect of FYM levels with or without fertilizer on soil pH and organic carbon (OC) at different growth stages of fingermillet (data are mean of 2 experiments);(FYM1, FYM2, FYM3 represent 3 levels of FYM applied viz. 7.5, 15 and 22.5 t/ha respectively; DAT= Days after transplanting).*

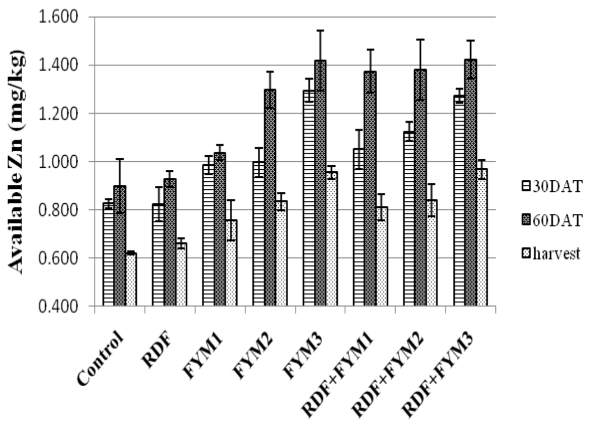

Fig. 2. *Effect of FYM levels with or without fertilizer on available (DTPA-extractable) zinc status in soil at different growth stages of fingermillet (data are mean of 2 experiments);(FYM1, FYM2, FYM3 represent 3 levels of FYM applied viz. 7.5, 15 and 22.5 t/ha respectively; DAT= Days after transplanting).*

was found more when FYM level were applied along with recommended NPK fertilizers (RDF), probably due to additional quantities of nutrients supplied through fertilizers in order to meet the demand of this crop. The results of the present study are in agreement with that of Sarwar *et al.,* (2008) who reported that organic materials like compost, FYM and Sesbania green manure when applied alone or in combination with chemical fertilizers, showed significant differences over control indicating an increasing trend in grain yield of rice and wheat. Hossain *et al.,* (2011) found that grain and straw yield of boro rice increased due to combined application of chemical fertilizers and organic manures,of which poultry manure@2.4t/ha gave the maximum response.

Conclusion

Different forms of zinc in soil were found to be existing in dynamic equilibrium with each other under the influence of different management practices and thus contributing towards the available Zn pool. Increase in the level of farmyard manure application (7.5 - 22.5 t/ha) increased the water soluble Zn while decreasing the residual Zn in soil, which indicates that more zinc in soil is mobilized towards its potentially available forms. The treatment RDF+FYM@ 22.5t/ha was found to be superior with respect to plant available status of Zn in soil and also yield of fingermillet.

ACKNOWLEDGEMENTS

ICAR is highly acknowledged for providing financial assistance in the form of Junior Research Fellowship to the main author for carrying out this research work.

REFERENCES

Behera, S.K. and Shukla, A.K. (2013). Depth-wise distribution of zinc, copper, manganese and iron in acid soils of India and their relationship with some soil properties. *Journal of the Indian Society of Soil Science,* 61: 244-252.

Dhaliwal, S.S., Manchanda, J.S., Walia, S.S. and Dhaliwal, M.K. (2013). Differential response of manures in transformation of DTPA and total zinc and iron in rice transplanted on light textured soils of Punjab. *International Journal of Science Environment and Technology,* 2: 300-312.

Goh, K.M. (2004). Carbon sequestration and stabilization in soils: implications for soil productivity and climate change. *Soil Science and Plant Nutrition*, 50: 467-476.

Hossain, M.A., Shamsuddoha, A.T.M., Paul, A.K., Bhuiyan, M.S.I. and Zobaer, A.S.M. (2011). Efficacy of Different Organic Manures and Inorganic Fertilizer on the Yield and Yield Attributes of Boro Rice. *The Agriculturists*, 9: 117-125.

Karaca, A. (2004). Effect of organic wastes on the extractability of cadmium, copper, nickel, and zinc in soil. *Geoderma,* 122: 297-303.

Lindsay, W.L. and Norvell, W.A. (1978). Development of a DTPA soil test for zinc, iron, Mn and copper. *Soil Science Society of America Journal*, 42: 421-428.

Ma, Y.B. and Uren, N.C. (1995). Application of a new fractionation scheme for heavy metals in soils. *Communication in Soil Science and Plant Analysis*, 26: 3291-3303.

Manivannan, S., Balamurugan, M., Parthasarathi, K., Gunasekaran, G., Ranganathan, L.S. (2009). Effect of vermicompost on soil fertility and crop productivity of beans (*Phaseolus vulgaris). Journal of Environmental Biology,* 30: 275-281.

Naidu, R. and Harter, R.D. (1998). Effect of different organic ligands on Cd sorption by extractability from soils. *Soil Science Society of America Journal*, 62: 644-650.

Sarwar, G., Schmeisky, H., Hussain, N., Muhammad, S., Ibrahim, M. and Ehsan S. (2008). Improvement of soil physical and chemical properties with compost application in rice-wheat cropping system. *Pakistan Journal of Botany,* 40: 275-282.

Shuman, L.M. (2005). Micronutrients. *Encyclopedia of Soils in the Environment*, pp 479-486.

Walkley, A.J. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science,* 37: 29-38.