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Kamini Kumari
Ph.D. Student. Department of Soil Science, Rajendra Agricultural University, Pusa, Samastipur, Bihar, India

Janardhan Prasad
Professor, Department of Soil Science, Rajendra Agricultural University, Pusa, Samastipur, Bihar, India

Ishwar Singh Solanki
Head, Indian Agricultural Research Institute Regional Station, Pusa, Samastipur, Bihar, India

Ravish Choudhary
TA, Indian Agricultural Research Institute Regional Station, Pusa, Samastipur, Bihar, India

Correspondence
Ravish Choudhary
TA, Indian Agricultural Research Institute Regional Station, Pusa, Samastipur, Bihar, India

Impact of long term application of crop residues and residual zinc on vertical distribution of organic carbon and DTPA-Zn

Kamini Kumari, Janardhan Prasad, Ishwar Singh Solanki and Ravish Choudhary

Abstract
The long-term effect of crop residue incorporation and residual Zn in rice-wheat cropping sequence was studied in calciorthents of Rajendra Agricultural University, Pusa, Samastipur, Bihar, India during 2011-12. The crop residue treatments are compared with residual $ZnSO_4$ application. Both organic carbon (OC) and DTPA-Zn contents decreased with increase in soil depth after completion of 18th cycle. Among crop residue and residual Zn treated plots, the ones with crop residues were found more effective in enhancing the OC and DTPA-Zn content in soil. The DTPA-Zn showed positive correlation with OC content indicating that application of crop residue increased organic matter that provides chelating agents for complication of native or added residual Zn.

Keywords: vertical distribution, organic carbon, DTPA-Zn, crop residue

Introduction
Among different micronutrients, Zn deficiency is widespread in the field, often limiting crop production in the country. Widespread occurrence of zinc deficiency in soil has been reported in many parts of our country, particularly where high yielding fertilizer responsive crops are being grown intensively. The calcareous soils of Bihar, occupying a sizeable area, are deficient in zinc to the extent of 80 % of tested soil samples (Sakal *et al*. 1996) [13]. The solubility and availability of zinc are highly dependent on pH. Deficiency of zinc may either be primary, due to low total content of Zn or secondary, caused by soil factors reducing their availability to plants. The emergence of zinc deficiency has generally been considered as secondary. The availability of Zn to plants as influenced by its distribution within the profile and other characteristics (Singh *et al*. 2013; Zhifan *et al.* 2010) [1] for an effective correlation of a micronutrient deficiency in the field, it is necessary to understand the reasons of its deficiency in the soil.

In order to achieve higher crop production, balanced and integrated nutrient supply and proper management of soil fertility is essential. Continuous use of inorganic fertilizers started to deplete the soil fertility, so now the time is to adopt organic sources like, crop residue incorporation to recycle the nutrient added to the previous crops. Application of different levels of crop residues along with common recommended dose of major nutrients for efficient growth of crop prevents the decline in OC and also bridges up the gap between potential and actual yield of rice and wheat. Further use of crop residue has favorable effect on depth wise chemical properties of soil due to supply of macro and micronutrients to the crop properly. Furthermore, the decomposition and mineralization of crop residue is a slow process which could match the nutrient requirement of a crop and, thus, the loss of precious plant food. Knowledge of depth wise distribution of micronutrient cation (Zn^{2+}) and OC in soil is helpful to understand the inherent capacity of soil to supply these nutrients to plant and their downward movement in soil. Moreover, roots of many crop plants go beyond the surface layer and, thus, draw part of their nutrient requirement from sub-surface layers of soil. Most of the work done on micronutrients in Bihar was confined to surface soils and, therefore, the present investigation was undertaken to study depth wise distribution of organic carbon and DTPA-Zn in calciorthents.

Materials and Methods
A field experiment was conducted during 1993-94 on light textured highly calcareous soil deficient in available zinc (0.56 mgkg^{-1}) at the Research Farm, Rajendra Agricultural University, Pusa (Bihar).

To begin with, the straw of wheat crop (Nov., 1993-April, 1994) was incorporated into the soil. The first crop of this long-term experiment on rice-wheat cropping system, i.e., paddy was transplanted in July, 1994 and harvested in Nov., 1994, followed by second crop of wheat (Nov., 1994-April, 1995). The experimental soil (0-15 cm) had pH (1:2) 8.5, EC 0.36 dSm^{-1}, organic carbon 0.62 gkg^{-1}, available N 236.1 $kgha^{-1}$, available P 19.7 $kgha^{-1}$, available K 100.0 $kgha^{-1}$ and available Zn 0.56 mgkg-1. Four levels of crop residues, viz. no crop residue (CR_0), 25% of straw produced (CR_{25}), 50% of straw produced (CR_{50}) and 100% of straw produced (CR_{100}) were applied as treatment in the main plots. The treatments were given to each crop every year. The main plot was divided into 4 sub-plots in which the treatments, viz. no Zn (Zn_0), 2.5 kg $Znha^{-1}$ ($Zn_{2.5}$), 5.0 kg $Znha^{-1}$ ($Zn_{5.0}$) and 10.0 kg $Znha^{-1}$ ($Zn_{10.0}$) were superimposed over crop residue levels. These four levels of Zn were applied only to first crop as a starter dose. The experiment was laid out in a split plot design with three replications and plot size 5.0 x 2.0 m^2. The recommended doses of NPK (120:60:40) were applied to each crop of rice and wheat as urea, single superphosphate and muriate of potash. Half of nitrogen and entire doses of P and K were applied at the time of transplanting of rice and sowing of wheat and remaining N fertilizer was applied in the equal splits at tillering and flower initiation stage. Rice and wheat crops were grown continuously under rice-wheat cropping system. The present experiment comprised 33rd crop of rice (July, 2010-Nov., 2010), 34th crop of wheat (Nov., 2010-April, 2011), 35th crop of rice (July, 2011-Nov., 2011) and 36th crop of wheat (Nov., 2011-April, 2012). Rajshree and HD 2733 were used as the test varieties of rice and wheat, respectively.

The soil samples (post-harvest soil of 36th wheat crop) were collected from all the 48 plots and different depths (0-15, 15-30, 30-60 and 60-90 cm), air-dried and pulverized to pass through 2.0 mm sieve and were analysed for the soil properties, organic carbon (OC) and Zn. The OC was determined by rapid titration method as described by Walkley and Black (1934) and the available micronutrient cation (Zn++) was extracted from the soil following DTPA soil test that was developed to identify near-neutral and calcareous soils with insufficient available Zn for maximum yields of crops. The extractant consists of 0.005*M* DTPA (diethylene triamine penta acetic acid), 0.1*M* tri ethanol amine (TEA), and 0.01*M* $CaCl_2$, with a pH of 7.3. The soil test consists of shaking 10 g of air-dry soil with 20 ml of extractant for 2 hours. The leachate is filtered, and Zn was measured in the filtrate by atomic absorption spectrophotometry (Lindsay and Norvell 1978) [5].

Results and Discussion

Depth wise distribution of available OC

The depth-wise available OC content in post-harvest soil after wheat (36th) crop as influenced by residual effect of starter Zn and continuous incorporation of crop residue of previous crop under rice-wheat cropping system are presented in Table 1. The OC content in surface soil (0-15 cm) was the highest varying from 0.69-1.11 $mgkg^{-1}$, whereas at 15-30, 30-60 and 60-90 cm depths, it systematically decreased ranging from 0.68-0.80, 0.67-0.79 and 0.58-0.66 $mgkg^{-1}$, respectively. The OC in soil increased significantly with increasing level of crop residue incorporation, i.e., from 0.71-1.06, 0.70-0.78, 0.69-0.77 and 0.58-0.64, whereas by the effect of residual Zn, it varied from 0.83-0.90, 0.74-0.76, 0.72-0.75 and 0.60-0.63 at all the depths of soil sampling in increasing order, respectively. The OC content in soil continuously decreased with increasing soil depth irrespective of treatment indicating that the soil which received crop residue had high OC in first two depths and 100 % crop residue receiving plots proved best source to enrich the OC content of the surface soil. Similar results supporting the findings of the present investigation on crop residues have been reported earlier (Kumar 2006; Sidhu and Sharma 2010; table 2012; Pandey 2012) [3, 8, 9].

The increasing level of crop residues significantly increased the OC content at all levels of residual Zn, except 25 % crop residue incorporation, whereas the increasing level of residual Zn could not increase the OC significantly at any level of crop residues incorporation at any depth. Residual effect of Zn application increased the biomass production, resulting in addition of higher quantity of roots and stubbles which might have built up the OC level in soil. The highest OC content of soil with crop residue incorporation might have been due to the fact that continuous addition of organic matter through crop residue increased the microbial population which enhanced the decomposition of crop residue resulting in increased OC content. Similar observations have been reported by Prasad *et al.* (2009) [10], Nayak *et al.* (2012) [6], Dhaliwal *et al.* (2012) [2] and Zhang *et al.* (2012) [19].

Table 1: Depth-wise distribution of available organic carbon content (gkg^{-1}) in post-harvest soil of wheat (36th) crop as influenced by crop residue and residual starter zinc.

Treatment	Organic Carbon Content (gkg^{-1})at Depth (cm)			
	0-15	15-30	30-60	60-90
CR_0 Zn_0	0.69	0.68	0.67	0.58
CR_0 $Zn_{2.5}$	0.70	0.70	0.69	0.58
CR_0 $Zn_{5.0}$	0.72	0.70	0.69	0.59
CR_0 Zn_{10}	0.74	0.73	0.72	0.60
Mean	0.71	0.70	0.69	0.58
CR_{25} Zn_0	0.77	0.74	0.71	0.60
CR_{25} $Zn_{2.5}$	0.77	0.74	0.71	0.60
CR_{25} $Zn_{5.0}$	0.79	0.75	0.72	0.61
CR_{25} Zn_{10}	0.82	0.76	0.73	0.63
Mean	0.79	0.74	0.71	0.61
CR_{50} Zn_0	0.88	0.76	0.74	0.62
CR_{50} $Zn_{2.5}$	0.90	0.77	0.74	0.62
CR_{50} $Zn_{5.0}$	0.92	0.78	0.75	0.63
CR_{50} Zn_{10}	0.94	0.78	0.76	0.65
Mean	0.91	0.77	0.75	0.63
CR_{100} Zn_0	0.98	0.78	0.76	0.63
$CR_{100}Zn_{2.5}$	1.08	0.78	0.77	0.63
$CR_{100}Zn_{5.0}$	1.08	0.79	0.78	0.64
$CR_{100}Zn_{10}$	1.11	0.80	0.79	0.66
Mean	1.06	0.78	0.77	0.64
CR_{0-100} Zn_0	0.83	0.74	0.72	0.60
CR_{0-100} $Zn_{2.5}$	0.86	0.74	0.72	0.61
CR_{0-100} $Zn_{5.0}$	0.88	0.75	0.74	0.62
	0.90	0.76	0.75	0.63
	0.07	0.04	0.04	0.05
Zn	CR_{0-100} Zn_{10}	0.02	0.05	0.04
CR x Zn	CD (0.05 %)CR	0.06	0.06	0.09

Depth wise distribution of DTPA-Zn

The depth wise available Zn content in post-harvest soil after wheat (36th) crop as influenced by residual effect of starter Zn and continuous incorporation of crop residue of previous crop under rice-wheat cropping system are presented in Table 2. The data revealed that increasing Zn levels significantly increased the available Zn status of surface soil (0-15 cm depth) from 0.53 to 0.76 $mgkg^{-1}$, though the values were below the critical level of 0.78 mgkg^{-1} for calcareous soils. The increase in available Zn due to crop residue incorporation was significantly higher with increasing levels of crop residue (0.40- 0.99 mgkg^{-1}), however, available Zn at zero crop residue (0.40 mgkg^{-1}) and at 25% crop residues incorporation (0.43 mgkg^{-1}) were statistically at par at 0-15 cm depth.

The available Zn content in surface soil (0-15 cm) varied from 0.38-1.21 mgkg^{-1}, whereas at 15-30, 30-60 and 60-90 cm depths, it ranged from 0.37-1.09, 0.36-1.01 and 0.30-0.96 mgkg^{-1}, respectively. Available Zn content in soil continuously decreased with increasing soil depth (Singh *et al.* 2011) [15] irrespective of treatment, indicating that Zn was accumulated in surface soil and very less or no downward movement of Zn in soil was observed, however, the rate of decrease was more in plots receiving crop residue (0.42-1.21 to 0.33-0.96 mgkg^{-1}) than in plots receiving no crop residues (0.38-0.42 to 0.30-0.35 mgkg^{-1}). It might be due to the complexion of Zn with organic matter which reduces the leaching loss. There was significant variation in Zn due to different treatments at all the depths, i.e. levels of crop residues, Zn and their interaction were found significant. The highest Zn content was recorded in treatments receiving 100 % crop residue and 10 kgha^{-1} of Zn. The available Zn in soil increased significantly with increasing levels of residual zinc (0.53-0.76, 0.51-0.70, 0.48-0.62 and 0.44-0.60 mgkg^{-1}) and crop residues (0.40-0.99, 0.39-0.93, 0.38-0.89 and 0.32-0.84 mgkg^{-1}) at all the depths of soil sampling, however, the availability of Zn at no crop residues and 25% crop residues was significantly at par at all the depths (0.40-0.43, 0.39-0.40, 0.38-0.38 and 0.32-0.34 mgkg^{-1}). The treatment effects were distinct with respect to zinc content at all the depths. The buildup of available Zn due to crop residues incorporation took place due to addition of Zn through crop residues and/or exploitation of native Zn by chelation through decomposition product of crop residues (Kumar 2006; Pandey 2012; Sakal *et al*. 1996; Singh *et al*. 2012; Walia *et al.* 2010) [3, 9, 13, 4, 16, 17].

The interaction effect between Zn and crop residue levels was significant which suggested that not only the addition of Zn through $ZnSO_4$ or crop residue incorporation enhanced the buildup of available Zn status of soil but also the solubilization of native Zn by the organic acids produced during the decomposition of crop residues was responsible for buildup of available Zn in post-harvest soils. Crop residue incorporation alone applied @100 % of straw produced for 18 complete years was able to raise the available Zn status of soil up to the extent of 0.78 mgkg^{-1} which is equivalent to the critical level of zinc. The crop residues applied to the extent of even 50 % of straw produced along with the starter dose of Zn (10 kgha^{-1}) or in the case of 100 % crop residue along with any four given treatments of Zn increased the available Zn content in soil above critical level (0.78 mgkg^{-1}) in surface soil particularly. The organic matter has also been reported to increase the efficiency of applied Zn as inorganic fertilizer (Kumar 2006; Prasad *et al.* 2010; Sidhu and Sharma 2010; Walia *et al.* 2010; Singh *et al*. 2011; Kumari and Singh 2012; Pandey 2012; Rathod *et al*. 2012) [3, 15, 4, 9, 12].

Table 2: Vertical distribution of DTPA- Zinc (mgkg-1) in post-harvest soil of wheat (36th) crop as influenced by crop residues and residual starter Zn

Treatment	Vertical Distribution of DTPA- Zinc (mgkg^{-1}) at Depth (cm)				
	0-15	15-30	30-60	60-90	Mean
CR_0 Zn_0	0.38	0.37	0.36	0.30	0.38
CR_0 $Zn_{2.5}$	0.40	0.38	0.37	0.31	0.37
CR_0 $Zn_{5.0}$	0.41	0.39	0.38	0.33	0.38
CR_0 Zn_{10}	0.42	0.40	0.39	0.35	0.39
Mean	0.40	0.39	0.38	0.32	0.37
CR_{25} Zn_0	0.42	0.39	0.38	0.33	0.39
CR_{25} $Zn_{2.5}$	0.43	0.40	0.39	0.34	0.39
CR_{25} $Zn_{5.0}$	0.44	0.40	0.38	0.35	0.39
CR_{25} Zn_{10}	0.44	0.41	0.38	0.35	0.40
Mean	0.43	0.40	0.38	0.34	0.39
CR_{50} Zn_0	0.52	0.50	0.41	0.44	0.47
CR_{50} $Zn_{2.5}$	0.58	0.57	0.48	0.49	0.53
CR_{50} $Zn_{5.0}$	0.68	0.66	0.58	0.55	0.62
CR_{50} Zn_{10}	0.95	0.90	0.72	0.69	0.82
Mean	0.68	0.66	0.55	0.54	0.61
CR_{100} Zn_0	0.78	0.76	0.74	0.73	0.75
$CR_{100}Zn_{2.5}$	0.91	0.90	0.88	0.80	0.87
$CR_{100}Zn_{5.0}$	1.05	0.98	0.94	0.84	0.95
$CR_{100}Zn_{10}$	1.21	1.09	1.01	0.96	1.07
Mean	0.99	0.93	0.89	0.84	0.91
$CR_{0-100}Zn_0$	0.53	0.51	0.48	0.44	0.49
$CR_{0-100}Zn_{2.5}$	0.58	0.56	0.53	0.48	0.54
$CR_{0-100}Zn_{5.0}$	0.65	0.61	0.56	0.53	0.59
$CR_{0-100}Zn_{10}$	0.76	0.70	0.62	0.60	0.67
Mean	0.63	0.59	0.55	0.51	0.57
CD (0.05%) CR	0.04	0.02	0.02	0.03	
Zn	0.05	0.01	0.02	0.02	
CR x Zn	0.08	0.03	0.03	0.05	
CV (%)	9.22	2.46	5.28	5.69	

Correlation coefficients of DTPA-Zn with organic carbon

The vertical distribution of OC was subjected to simple correlation with depth wise DTPA-Zn distribution in post-harvest soil (Table 3). The correlation values indicated that OC content at all depths were positively and significantly correlated with their corresponding values of DTPA-Zn. The results suggest that the rice-wheat cropping system has already attained a state of equilibrium as is evident by highly positive and significant correlation coefficient values throughout the soil profile under investigation (Kumar 2006; Prasad *et al.* 2010; Sidhu and Sharma 2010; Singh *et al.* 2011; Pandey 2012; Singh *et al.* 2012) [3, 15, 8, 15, 9, 4, 16].

Table 3: Correlation coefficients of DTPA-Zn with organic carbon at different depths

Organic carbon at different depths (cm)	DTPA-Zn at different depth (cm)			
	0-15	15-30	30-60	60-90
0-15	0.939**	0.948**	0.944*	0.966*
15-30	0.798**	0.801**	0.761**	0.811**
30-60	0.902*	0.906*	0.882**	0.918**
60-90	0.868*	0.863*	0.805*	0.850*

Conclusions

Crop residue incorporation alone applied @100 % straw produced for 18 complete years was able to raise the available Zn status of soil. The crop residues applied to the extent of even 50 % of straw produced along with the starter dose of Zn at least 10 kg $Znha^{-1}$ or in the case of 100 % crop residue along with any four given treatments of Zn increased the available Zn content in soil above critical level (0.78 mgkg-1) in surface soil particularly. The OC content in soil continuously decreased with increasing soil depth irrespective of treatment, indicating that the soil which received crop residue had high OC in first two depths, and 100 % crop residue receiving plots proved best source to enrich the OC content of the surface soil.

References

1. Chen ZhiFan, Wang YanSong, Duan HaiJing, Zhao ZiNan. Vertical distribution characteristics of heavy metals in agricultural soil profiles under rice-wheat system in Heigangkou Yellow River Irrigation Region. Chinese Journal of Eco-Agriculture. 2012; 20:480-87.
2. Dhaliwal SS, Sadana US, Walia SS, Sidhu SS. Long-term effects of manures and fertilizers on chemical fractions of Fe and Mn and their uptake under rice-wheat cropping system in North-west India. International Journal of Agricultural Sciences. 2012; 8:98-107.
3. Kumar S. Influence of green manuring on chemistry of native zinc in calcareous soil under rice-wheat system. Ph.D. Thesis, Department of Soil Science, R.A.U., Pusa, Bihar (India), 2006.
4. Kumari R, Singh AP. Effect of zinc and crop residue management on fractioned for different pools of zinc in an alluvial soil. Environment and Ecology. 2012; 30:1485-87.
5. Lindsay WL, Norvell WA. Development of DTPA soil test for Zn, Fe, Mn and Cu. Soil Science Society of America Journal. 1978; 42:421-28.
6. Nayak AK, Gangwar B, Shukla AK, Mazumdar SP, Kumar A, Raja R, et al. Long-term effect of different integrated nutrient management on soil organic carbon and its fractions and sustainability of rice-wheat system in Indo Gangetic Plains of India. Field Crops Research. 2012; 127:129-39.
7. Ghimire R, Adhikari KR, Zueng Sang C, Shah SC and Dahal KR. Soil organic carbon sequestration as affected by tillage, crop residue, and nitrogen application in rice-wheat rotation system. Paddy and Water Environment. 2012; 10:95-102.
8. Sidhu GS, Sharma BD. Diethylenetr iamine pentaacetic acid-extractable micronutrients status in soil under a rice-wheat system and their relationship with soil properties in different agroclimatic zones of Indo-Gangetic Plains of India. Communications in Soil Science and Plant Analysis. 2010; 41:29-51.
9. Pandey AK. Long term effect of organic and inorganic fertilizers on the distribution and transformation of S, Zn and Boron in calcareous soil. Ph.D. Thesis, Department of Soil Science, RAU, Pusa, 2012, 200.
10. Prasad RK, Kumar V, Mandal K, Kumar R. Long term application of zinc and crop residues on yield and uptake of micronutrients in transplanted rice under rice-wheat cropping system in calciorthents. Environment and Ecology. 2009; 27:1440-43.
11. Prasad RK, Kumar V, Prasad B, Singh AP. Long term effect of crop residues and zinc fertilizer on crop yield, nutrient uptake and fertility build up under rice-wheat cropping system in calciorthents. Journal of the Indian Society of Soil Science. 2010; 58:205-11.
12. Rathod DD, Meena NC, Patel KP. Evaluation of Different zinc-enriched organics as source of zinc under wheat-maize (fodder) cropping sequence on zinc deficient Typic Haplustepts. Journal of the Indian Society of Soil Science. 2012; 60:50-55.
13. Sakal R, Singh AP, Sinha RB, Bhogal NS. Twenty five years of research on micro and secondary nutrients in soils and crops of Bihar. Faculty of Agriculture, R.A.U, Pusa. 1996, 1-135.
14. Singh G, Singh S, Singh SS. Integrated nutrient management in rice and wheat crop in rice-wheat cropping system in lowlands. Annals of Plant and Soil Research. 2013; 15:1-4.
15. Singh YV, Dhar DW, Agarwal B. Influence of organic nutrient management on Basmati rice-wheat- green gram cropping system. Indian Journal of Agronomy. 2011; 56:169-75.
16. Singh JP, Kaur J, Mehta DS, Narwal RP. Long-term effects of nutrient management on soil health and crop productivity under rice-wheat cropping system. Indian Journal of Fertilizers. 2012; 8:28-48.
17. Walia MK, Walia SS, Dhaliwal SS. Long-term effect of integrated nutrient management of properties of typic ustochrept after 23 cycles of an irrigated rice -wheat system. Journal of Sustainable Agriculture. 2010; 34:724-43.
18. Walkley A, Black CA. An examination of the Degtjareff methods for determination of soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934; 34:29-38.
19. Zhang SW, Zhang WY, Wang L, Zhu LQ, Gu KJ, Zhang HYand Bian XM. Influences of tillage mode and straw-returning on accumulation of organic carbon in soil of wheat field. Acta Agriculturae Jiangxi. 2012; 24:6-9.