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Impact of Conservation Agriculture on Vertical Distribution of DTPA-Zinc and Organic Carbon of Soil

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A B S T R A C T

A long-term field experiment was carried out in alluvial soil with conservation agriculture practices like Zero tillage, Permanent bed and Conventional tillage to see the impact on vertical distribution of DTPA-Zn and Organic carbon of soil under rice based cropping systems. After completion of 5th cycle of experiment (2016), soil samples were collected from each plot and analysis processes were executed. The results were revealed that vertical distribution of DTPA-Zn and Organic carbon content, decreased with increases of soil depth. Maximum DTPA-Zn (2.02 mg/kg) and Organic carbon content (0.61%) of soil was recorded in surface layer (0-15 cm depth) under the treatment Zero tillage which was statistically similar to permanent bed and it was decreased to 0.49 mg/kg and 0.17% respectively due to conventional tillage. Whereas, Rice-Lentil cropping system was also significantly restrict the downward movement of DTPA-Zn and Organic carbon content through the soil profile as compare to Rice-Wheat and Rime-Maize. The DTPA-Zn showed positive correlation with Organic carbon content, indicating that retention of crop residue and minimum disturbance of surface soil under conservation agriculture increases the organic matter content that provides chelating agents for complexation of native Zn. In conclusion, zero tillage and permanent bed practices significantly restrict the movement of DTPA-Zn and Organic carbon to the lower depth of soil as compare to conventional tillage.

Introduction

Enhanced removal of zinc as a consequence of adaptation of high yielding varieties and intensive cropping together with a shift towards high analysis NPK fertilizers has caused decline in the level of labile zinc in soils. Role of micronutrients in balanced plant nutrition is well established. Micronutrients are very important for maintaining soil health and also in increasing productivity of crops (Rattan *et al.*, 2009). However, exploitive nature of modern agriculture involving use of high analysis NPK fertilizers coupled with limited use of organic manure and less recycling of crop residues are important factors contributing towards accelerated exhaustion of micronutrients from the soil (Sharma and Choudhary, 2007). Thus, the deficiency of micronutrients has become a major constraint to productivity and sustainability in many Indian soils. The availability of micronutrients to plants is also influenced by the distribution within the soil profile (Singh and Dhankar, 1989). The knowledge of profile distribution of micronutrient cations is important as roots of many plants go beyond the surface layer and thus draw a part of the nutrient requirement from the subsurface layers of the soils (Athokpam *et al.,* 2016). Deficiency of zinc may either be primary due to low total content of Zn or secondary caused by soil factors reducing its availability to plants. The emergence of zinc deficiency has generally been considered as secondary. The availability of zinc to plants is influenced by its distribution within the soil profile and other soil characteristics (Singh *et al.,* 1989 and Kumar *et al.,* 2010). For an effective correction of a micronutrient deficiency in the field, it is necessary to understand the reasons of its deficiency in the soil.

Knowledge of depth-wise distribution of micronutrient cations like zinc and organic carbon in soil is helpful in understanding the inherent capacity of soil to supply these nutrients to plant and their downward movement in the soil. Moreover, roots of many crop plants go beyond the surface layer and thus draw part of their nutrient requirement from subsurface layers. Most of the work on micronutrient studies in Bihar was confined to surface soils and therefore, the present investigation was undertaken to study the depth-wise distribution of organic carbon and DTPA-Zn in Calciorthents under the long-term effect of green manuring.

This conversion process gave rise to the three main principles applied in ecological oriented conservation agriculture (CA): crop diversification, minimum soil disturbance, and permanent soil cover; all aiming to increase and sustain soil organic matter (Johan and Corrie, 2015). Conventional tillage (CT) increase soil erosion and degradation processes, which cause significant losses in soil organic matter content. These processes promote the deterioration of chemical, physical and biological soil properties; and, in consequence, the soil quality. Depth-wise vertical distributions of micronutrient cations like zinc and organic carbon in soil is helpful in understanding the inherent capacity of soil to supply these nutrients to plant and their downward movement in the soil. Moreover, roots of many crop plants go beyond the surface layer and thus draw part of their nutrient requirement from subsurface layers. Most of the work on micronutrient studies in Bihar was confined to surface soils and therefore, the present investigation was undertaken to study the depth-wise vertical distribution of organic carbon and DTPA-Zn in alluvial soil under the long term effect of conservation agriculture (Kumar *et al.,* 2010).

Materials and Methods

Soil sampling was carried out, were collected from different depths (0-15, 15-30, 30-45 and 45-60 cm) with the help of post hole auger. These samples were air dried and processed to pass through 2 mm mesh sieve and stored in polyethylene bags for analysis. A long-term experimental field was initiated in *kharif* 2011 on fine sandy loam soil at Bihar Agricultural University Research Farm, Sabour. The experimental soil had pH 7.36, EC 0.30 dSm^{-1}, organic carbon 0.53 %, CEC 8.2 [cmol (p+) kg^{-1}], and available Zn 1.99 mg kg^{-1}. The experiment was laid out establishment techniques (T) and cropping systems (S)in a split plot design with following treatment combination details:T1S1 - Rice-Wheat +

Zero tillage, T1S2 - Rice-Maize + Zero tillage, T1S3 - Rice-Lentil + Zero tillage, T2S1 - Rice-Wheat + Permanent bed, T2S2 - Rice-Maize + Permanent bed, T2S3 - Lentil + Permanent bed, T3S1 - Rice-Wheat + Conventional tillage, T3S2 - Rice-Maize + Conventional tillage and T3S3 - Rice-Lentil + Conventional tillage. The available Zn in these soil samples extracted with DTPA solution (Lindsay and Norvell 1978) was determined using Atomic Absorption Spectrophotometer (ECIL-4141M and Elico-SL 194) and organic carbon was determined by rapid titration method, Walkley and Black (1934).

Results and Discussion

Vertical Distribution of DTPA-extractable Zinc

So far as the vertical distribution of DTPA-Zn is concerned, large variation was obtained among the effectiveness of different treatments. The depth-wise distribution of DTPA-Zn in post-harvest soil after completion of 5 years of conservation agriculture as influenced by different treatments has been presented in Table 1 and ranged from 1.45 to 2.09, 0.95to 1.40, 0.66 to 0.80 and 0.47 to 0.56 mg/kg with soil depth 0-15, 15-30, 30-45 and 45-60 cm respectively. The interaction effect were found non-significant but the highest amount of DTPA-Zn (2.09 mg/kg) in surface soil (0-15cm) was noted under treatment T1S3 where Rice-Lentil grown with zero tillage technique. Whereas, the lowest DTPA-Zn (1.45 mg/kg) was recorded in treatment Rice-Maize grown under conventional tillage system (T3S2).The impact of establishment techniques (Fig. 1.) on DTPA-Zn were recorded statistically significant and varied from 1.60 to 2.02, 1.03 to 1.22, 0.69 to 0.76 and 0.49 to 0.56 mg/kg under 0-15, 15-30, 30-45 and 45- 60 cm depth of soil, respectively. The lowest surface soil DTPA-Zn 1.60 mg/kg was recorded in the treatment conventional tillage and significantly inferior by permanent bed 1.91 mg/kg. Zero tillage and permanent bed treatment were also found statistically at par with each other. However, the effects of cropping systems on depth-wise distribution of DTPA-Zn (Fig. 2.) were also found significant up-to the 30 cm depth of soil after completion of 5 years of the conservation agriculture experiment. The vertical distribution of DTPA-Zn were ranged between 1.71 to 1.95, 1.06 to 1.28, 0.71 to 0.77 and 0.51 to 0.54 mg/kg soil under 0-15, 15-30, 30-45 and 45-60 cm depth respectively due to different rice based cropping systems. The impact of Rice-Lentil cropping system was obtained statistically significant with respect to DTPA-Zn content of soil as compare to Rice-Maize and Rice-Wheat cropping systems. The relative high value of Zn in the surface horizon might be due to variable intensity of pedogenic processes and more complexions with organic matter that provided chelating agents for complexion and coincided with the distribution pattern of organic carbon, as suggested by Gupta *et al.*, (2003). Choudhari *et al.*, (2018), Sharma *et al.*, 2013 and Dinesh and Vishnoi 2009 reported the content of micronutrients (Zn, Fe, Cu and Mn) were found in sufficient amount in all the surface horizons of soil and vertical distribution of all these nutrients was uneven. Similarly, Athokpam *et al.*, (2016) indicated the content of DTPA-extractable Zn were higher in surface horizons and decreased with depth in most of the profiles. Surface horizons contain sufficient amount of DTPA-extractable micronutrient cations.

Vertical distribution of organic carbon

So far the vertical distribution of organic carbon is concerned, large variation were obtained at all the treatment combinations. The depth-wise distribution of organic carbon as influenced by different treatment after 5 year completion of the experiment has been presented in Table 2. Effect of establishment techniques (T) and cropping systems (S) on vertical distribution of soil organic carbon was found statistically non significant under conservation agriculture. Nevertheless it varies from 0.48 to 0.63 %, 0.38 to 0.46 %, 0.22 to 0.28 % and 0.16 to 0.18 % by the soil depth 0-15, 15-30, 30-45 and 45-60 cm, respectively due to establishment technique and cropping system combinations. The data illustrated in Figure 3. Indicated the effects of establishment technique like zero tillage, permanent bed and conventional tillage on vertical distribution of organic carbon were found statistically significant with two depth 0-15 and 15-30 cm.

Table.1 Effect of establishment techniques (T) and cropping systems (S) on depth-wise distribution of DTPA-Zn (mg kg^{-1}) content in post-harvest soil as influenced by conservation agriculture at the end of the 5^{th}cycle under rice cropping system

Treatment combinations	Depth-wise distribution of DTPA-Zn (mg kg^{-1})			
	0-15 cm	15-30 cm	30-45 cm	45-60 cm
T1S1	2.04	1.14	0.75	0.55
T1S2	1.93	1.11	0.72	0.55
T1S3	2.09	1.40	0.80	0.56
T2S1	1.98	1.08	0.75	0.53
T2S2	1.76	1.12	0.74	0.53
T2S3	2.00	1.33	0.77	0.53
T3S1	1.57	1.02	0.67	0.47
T3S2	1.45	0.95	0.66	0.47
T3S3	1.77	1.11	0.75	0.53
SEm(±)	0.13	0.08	0.05	0.04
CD (P=0.05)	NS	NS	NS	NS

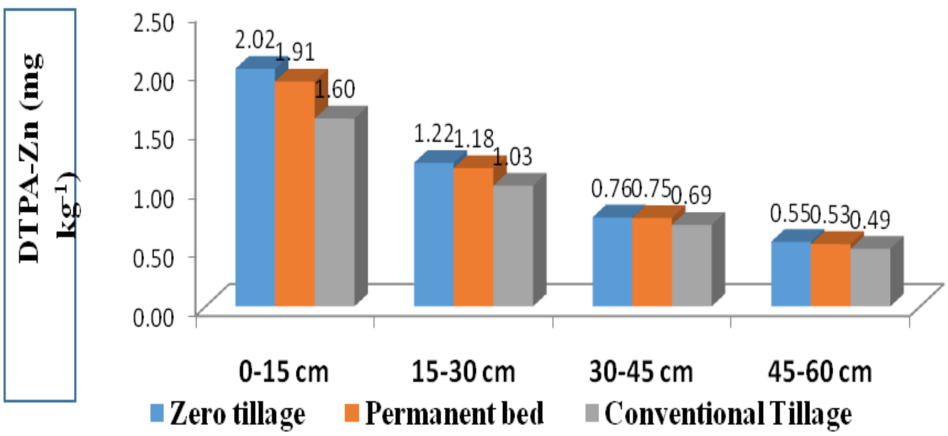
Table.2 Effect of establishment techniques (T) and cropping systems (S) on depth-wise distribution of organic carbon (%) content in post-harvest soil as influenced by conservation agriculture at the end of the 5^{th}cycle under rice cropping system

Treatment combinations	Depth-wise distribution of organic carbon (%)			
	0-15 cm	15-30 cm	30-45 cm	45-60 cm
T1S1	0.61	0.44	0.26	0.18
T1S2	0.60	0.45	0.28	0.18
T1S3	0.63	0.46	0.24	0.17
T2S1	0.58	0.42	0.25	0.17
T2S2	0.57	0.44	0.28	0.18
T2S3	0.60	0.46	0.27	0.18
T3S1	0.49	0.41	0.23	0.16
T3S2	0.48	0.38	0.25	0.17
T3S3	0.50	0.42	0.22	0.16
SEm(±)	0.03	0.04	0.02	0.01
CD (P=0.05)	NS	NS	NS	NS

Table.3 Correlation among the vertical distribution of DTPA-Zn and O.C

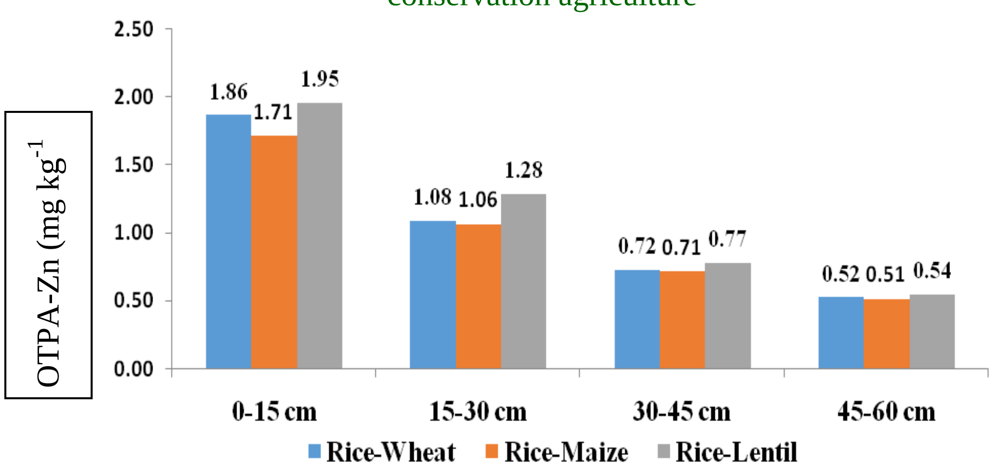
	DTPA-Zn				
	Soil depth	(0-15 cm)	(15-30 cm)	(30-45 cm)	(45-60 cm)
O.C	(0-15 cm)	.909**	.773*	.786*	.851**
	(15-30 cm)	.834**	.865**	.826**	.822**
	(30-45 cm)	.348	.134	.103	.360
	(45-60 cm)	.551	.428	.351	.462
	* and ** denote significant at 5 and 1% level, respectively.				

Fig.1 Effect of establishment technique on vertical distribution of DTPA-Zn (mg kg^{-1}) in soil under conservation agriculture



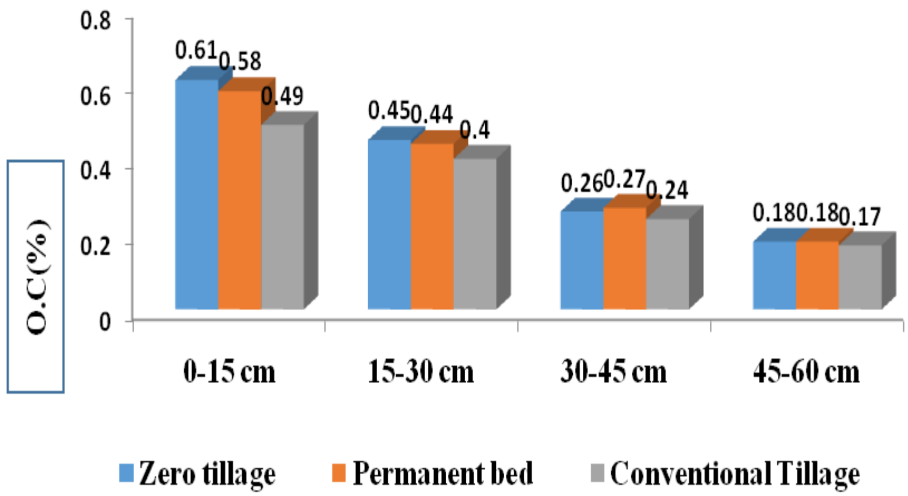
SEm(±)	0.07	0.04	0.03	0.02
CD (P=0.05)	0.20	0.11	NS	NS

Fig.2 Effect of cropping system on vertical distribution of DTPA-Zn (mg kg^{-1}) in soil under conservation agriculture



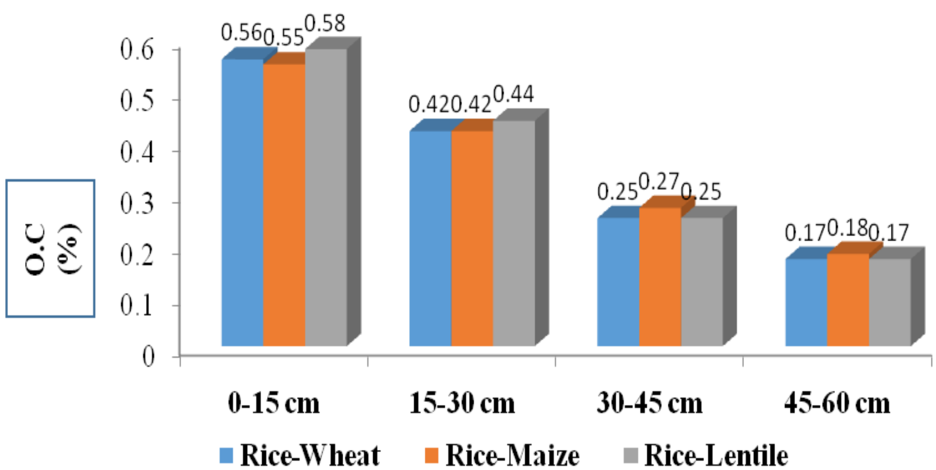
SEm(±)	0.08	0.05	0.03	0.02
CD (P=0.05)	0.16	0.10	NS	NS

Fig.3 Effect of establishment technique on vertical distribution of organic carbon (%) in soil under conservation agriculture



SEm(±)	0.02	0.02	0.01	0.01
CD (P=0.05)	0.05	0.06	NS	NS

Fig.4 Effect of cropping systems on vertical distribution of organic carbon (%) in soil under conservation agriculture



SEm(±)	0.02	0.02	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS

The organic carbon content ranged from 0.49 to 0.61, 0.40 to 0.45, 0.24 to 0.27 and 0.17 to 0.18 % under the 0-15, 15-30, 30-45 and 45-60 cm soil depth, respectively due to ZT, PB and CT treatments. It was further observed that effect of zero tillage (ZT) and permanent bed (PB) were significantly superior over conventional tillage (CT) as well as ZT and PB statistically at par with each other.

However, the impact of different cropping system treatments were increased from 0.55-0.58, 0.42-0.44, 0.25-0.27 and 0.17-0.18 % under the soil depth 0-15, 15-30, 30-45 and 45-60 cm, respectively.

It was apparently visualized from the data in Table 2 and Figure 3 and 4 that organic carbon content decreased with soil depth irrespective of treatments. The soil which received organic carbon matter through retention of crop residues had high organic matter in first two depths. Hence proved zero tillage (ZT) and permanent bed (PB) are the best rice establishment techniques. It might be due to more crop residue retention under Conservation Agriculture. High amount of organic carbon in surface then in sub-surface soil has resulted from crop residue recycling over the year by plant and subsequent organic matter accumulation was reported that (Katyal and Agarwal, 1982). Kumar *et al.*, (2010), Bhatnagar *et al.*, (2003) and Piccolia *et al.*, (2016) reported that a higher amount of organic carbon in surface than in subsurface soils have resulted from its recycling.

Correlation among depth-wise distribution of Zinc Vs organic carbon

The vertical distribution of DTPA-zinc Vs organic carbon correlation co-efficient value (r) was significantly and positively correlated with organic carbon at two depth 0-15 and 15-30 cm. It is also conspicuous from the data that highest correlation co-efficient value (r_2 0.909**) was obtained between DTPA-Zn and organic carbon content of surface (0-15cm) soil (Table 3).

This suggested that conservation agriculture based management practices such as zero tillage and permanent bed like establishment technique with crop residue retention year by year may hold potential to increase organic matter content of soil and has a marked impact on the enhancement of DTPA-Zn content at all the soil depths. The impacts of organic carbon build up at different depths were very much clearing on DTPA-Zn as lower depths at evident from positive and significant correlation. Similar results were also reported by Kumar *et al.*, (2010) and Choudhari *et al.*, (2018) whereas; Dinesh and Vishnoi 2009 reported the physico-chemical characteristics of these soils were correlated with micronutrient contents. A significant correlation of these micronutrients was found with organic carbon contents of the soils.

Similarly, Patangray *et al.*, (2018) observed Soil organic carbon shows significant and positive correlation with zinc (r = 0.61) and copper (r = 0.51) whereas it was non-significant and positive with all other nutrients.

In conclusion, the vertical distribution of organic carbon and DTPA-Zn are concerned, large variation was obtained at all the treatments, where establishment techniques like zero tillage, permanent bed, conventional tillage or different rice based cropping systems adopted under conservation agriculture. Organic carbon and DTPA-Zn content decreased with soil depth irrespective of treatments, although, the soil which received crop residue had high organic carbon and DTPA-Zn in first two depths. The accumulation of higher amount of organic carbon in surface and subsurface soils has resulted from its recycling, over the years by subsequent crop residue accumulation under zero tillage and permanent bed technique. The effect of treatments was also distinct at all the depth with respect to organic carbon and DTPA-Zn content of soil.

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