Original Research Article

Vertical distribution of DTPA extractable micronutrients in two distinct soils of Central India under diverse land-uses

ABSTRACT

Crop productivity and health of human and animals are greatly influenced by availability of micronutrients in the soil. Understanding the nature and extent of deficiency problems of these nutrients is useful in improving the fertilizerrecommendations by inclusion of micronutrients in the fertilization schedule. This investigation carried out to evaluate the vertical variability in status of DTPA extractable micronutrients in two contrast soil types (medium black and alluvial soils) under different land uses. Soil sample were collectedin triplicate from six distinct land use practices (forest, uncultivated, soybean-wheat, rice-wheat, soybean-chickpea and maize-wheat system)from Jabalpur (medium black soil) and Gwalior (alluvial soil) region at four depths (0-15, 15-30,30-45 and 45-60 cm)after harvest of *rabi*season crops during2020-21. Statistical analysis of data was done using factorial RBD considering soil type (medium black soil and alluvial soil) as factor A and land use practices as factor B.It was found that contents of DTPA extractable micronutrients (zinc, copper, iron and manganese) were found maximum under forest land in both the soils at 0-15 cm depth and decreased with increase in soil depths. It was also noted that under different land use practices DTPA extractableZn, Mn and Cuwere higher in medium black soil as compared toalluvial soil, however available Fefound higher in alluvial soil across the soil depths.The results clearly indicated thatZn, Fe,Mn was significantly affected by different soil type except Cu are non significant. Zn,Cu,Mnwas significantly affected by different land use practices but Fe are nonsignificant.

Keywords: Land Uses, DTPA-Extractable Micronutrient, Available Sulphur, Soil depth, Black soil, Alluvial Soil.

1. INTRODUCTION

In india, about 51.09% of the land is under cultivated land, 3.92% 21.81% under forest land. About 5.17% of the total land is uncultivated waste. Indian soils have become deficient not only in major plant nutrients but also in micronutrients such as zinc, boron and to a limited extent iron, manganese and copper. Conversion of land-uses resulted in change in soil characteristics which in turn affects the soil fertility (Onwudike*et al*., 2015).Dhaliwal *et al.* (2021) obtained that the agricultural land-uses had a substantial impact on DTPA-extractable micronutrients. Regardless of land-uses, the concentration of accessible Fe declined dramatically with soil depth. However, the horticultural land had the highest concentration of accessible Mn, followed by cropland and uncultivated land in both the 0-15 and 15-30 cm soil layers, whereas cropland and uncultivated land had an increase in available

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Mncontent with increasing soil depth. The levels of micronutrients were found higher in horticulture and farmland than in uncultivated soils.

Role of micronutrients in balanced plant nutrition is well established. However, exploitive nature of modern agriculture involving use of high analysis NPK fertilizers coupled with limited use of organic manures and less recycling of residues is important factors contributing accelerated exhaustion of micronutrients from soil. Micronutrients (Zn, Fe, Cu and Mn) play important role to maintain soils fertility. Soil characterization in relation to evaluation of micronutrient status of the soils of an area is an important aspect in context of sustainable agriculture production. Because of non supply of micronutrients in the soil is a natural phenomenon for deficiency in the soil. The stagnation in crop productivity can not be boosted without invidious use of micronutrient fertilizers to overcome deficiencies/imbalances. In soils of Madhya Pradesh, enhanced removal of micronutrients as a consequences of adoption of high yielding varieties and intensive cropping together with a shift towards high analysis NPK fertilizers has caused decline in the level of micronutrients (Athokpam ~~H.~~ *et. al.* 2018).

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2. MATERIALS AND METHODS

The study were carried out during 2020-21 under different land uses across the soil type at the Research Farms of Jawaharlal Nehru KrishiVishwaVidyalaya, Jabalpur, Madhya Pradesh.Jabalpur is situated (23°10'N latitude and 79°57" E longitude) at 393 meters above the mean sea level.The temperature during sampling time varies from 25 to 35°C and Gwalior region is a typically semi-arid, characterized by extremes of temperature during both summers and winters. During summers, the temperature may go as high as 48^0C while in winters, it may fall as low as -1.0^0C. The possible technical precautions as prescribed for standard soil sampling have been followed. Sampleswere collected from different location Jabalpur and Gwalior region at selected sites (deep black soil and Alluvial soil) under different land use practices viz. Forest, uncultivated, soybean-wheat, rice-wheat, soybean- chickpea and maize-wheat from four distinct depths i.e. 0-15, 15-30, 30-45 and 45-60 cm after harvest of Rabi crop during crop year 2020-21.Collected soil samples were used for study of DTPA extractable micronutrient and Available Sulphur.DTPA extractable Zn, Fe, Mn and Cu were determined by 0.005 M DTPA, 0.01M

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$CaCl_2.2H_2O$ and 0.1M Triethanol amine (TEA) at adjusted pH of 7.3 and analyzed by Atomic Absorption Spectrometer using appropriate hallow cathode lamps (Lindsay and Norvell,1978).

3.RESULT AND DISCUSSION

3.1 DTPA extractable Zinc

Data related to the DTPA extractable zinc (DTPA-Zn) in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 1. The results clearly indicated that DTPA extractable zinc was significantly affected by different land use practices and soil type. It is evident from data the DTPA extractable zinc content was found higher under black soil compare to alluvial soil. It was also found that irrespective of different land uses the DTPA extractable zinc decreased with depths. Data further showed that the content of DTPA extractable zinc at different soil depths upto 0-60 cm varied from 0.24 to 0.83 mg kg^{-1} in black soil and 0.20 to 0.71 mg kg^{-1} in Alluvial soil. It is also evident from the data thattheDTPA extractable zinc (DTPA-Zn) of different land uses practices ranged from 0.52 to 0.83 at 0-15 cm, 0.37 to 0.68 at 15-30 cm, 0.28 to 0.56 at 30-45 and 0.24 to 0.52 mg kg^{-1}at 45-60 cm, respectively under black soil and 0.40 to 0.71 0-15cm, 0.33 to 0.64 15-30cm, 0.24 to 0.55 30-45 cm and 0.20 to 0.51 mg kg^{-1} 45-60 cm in Alluvial soil. Numerically the maximum values of DTPA-Zn (0.83,0.68,0.56 and 0.52 mg kg^{-1}) at respective soil depths were obtained under forest soil, while minimum (0.52,0.37,0.28 and 0.24 mg kg^{-1}) at 0-15, 15-30, 30-45 and 45-60 cm under uncultivated land in black soil and alluvial soil maximum values of DTPA - Zn (0.71,0.64,0.55 and 0.51 mg kg^{-1}),while minimum (0.40,0.33,0.24 and 0.20 mg kg^{-1}) at respective depth under uncultivated land. Interaction effect was also non-significant which were at par among themselves. There was significant increase in availability of zinc with increase in organic carbon as zinc forms soluble complexes (chelates) with soil organic matter component (Khursheed*et al*., 2013).

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Table 1: Effect of land use practices on DTPA extractable zinc of black and alluvial soils at different depths.

Soil depth (cm) Factor B (Land Uses)	DTPA extractable Zinc (mg kg^{-1})											
	0-15			15-30			30-45			45-60		
	Factor A (Soil types)											
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Forest	0.83	0.71	0.77	0.68	0.64	0.66	0.56	0.55	0.56	0.52	0.51	0.52
Uncultivated	0.52	0.40	0.46	0.37	0.33	0.35	0.28	0.24	0.26	0.24	0.20	0.22
Soybean- wheat	0.61	0.49	0.55	0.46	0.40	0.43	0.34	0.31	0.33	0.30	0.27	0.29
Rice -wheat	0.59	0.47	0.53	0.44	0.38	0.41	0.32	0.29	0.31	0.28	0.25	0.27
Soybean-Chickpea	0.67	0.55	0.61	0.52	0.46	0.49	0.40	0.37	0.38	0.36	0.33	0.34
Maize-wheat	0.57	0.45	0.51	0.42	0.36	0.39	0.30	0.27	0.28	0.26	0.23	0.24
Mean	0.63	0.51		0.48	0.43		0.37	0.33		0.33	0.29	
	A	B	A x B	A	B	A x B	A	B	A x B	A	B	A x B
SE m±	0.007	0.012	0.016	0.005	0.009	0.013	0.004	0.007	0.010	0.005	0.009	0.012
CD (*p=0.05*)	0.020	0.034	NS	0.016	0.027	NS	0.011	0.020	NS	0.014	0.025	NS

S1: Deep black soil S2: Alluvialsoil

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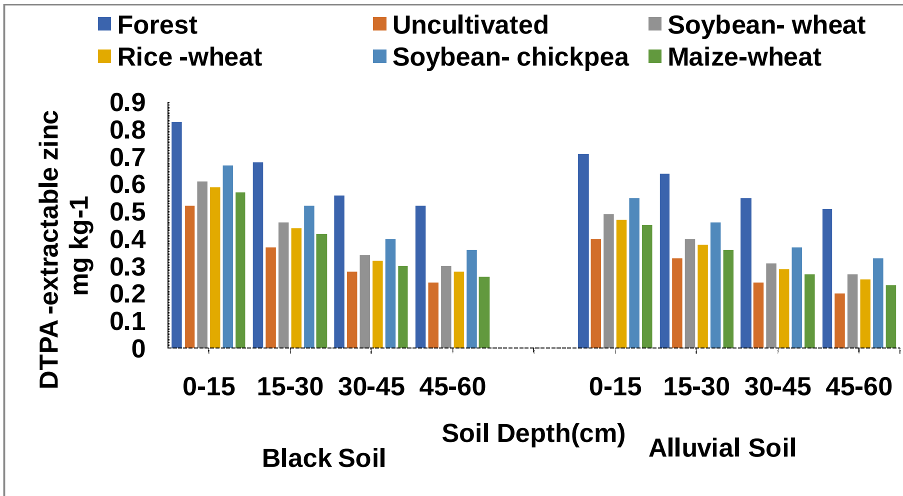

Figure 1: Effect of land use practices and soil type on DTPA-extractable Zinc.

3.2 DTPA extractable copper

Data related to the DTPA extractable copper (DTPA-Cu) in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 2. The results clearly indicated that DTPA extractable copper was nNon significantly affected by different land use practices and significantly affected by soil type but different land uses was affected significantly at 30-45 and 45-60 cm depths. It is evident from data the DTPA extractable copper content was found higher under black soil compare to alluvial soil. It was also found that irrespective of different land uses the DTPA extractable copper decreased with depths. Data further showed that the content of DTPA extractable copper at different soil depths upto 0-60 cm varied from 0.80 to 1.50 mg kg^{-1} in black soil and 0.75 to 1.47 mg kg^{-1} in Alluvial soil. It is also evident from the data that the DTPA extractable copper (DTPA-Cu) of different land uses practices ranged from 1.36 to 1.50 at 0-15 cm, 1.36 to 1.46 at 15-30 cm, 0.83 to 0.96 at 30-45 and 0.80 to 0.90 mg kg^{-1}at 45-60 cm, respectively under black soil and 1.34 to 1.47 0-15cm, 1.32 to 1.43 15-30 cm, 0.79 to 0.89 30-45 cm and 0.75 to 0.81 mg kg^{-1}45-60 cm in Alluvial soil. Numerically the maximum values of DTPA-Cu (1.50,1.46,0.96 and 0.90 mg kg^{-1}) at respective soil depths were obtained under forest soil, while minimum (1.36,1.36,0.83 and 0.80 mg kg^{-1}) at 0-15, 15-30, 30-45 and 45-60 cm under soybean- chickpea in black soil and alluvial soil maximum values of DTPA- Cu (1.47,1.43,0.89 and 0.81 mg kg^{-1}) forest land,while minimum (1.34,1.32,0.79 and 0.75 mg kg^{-1}) at respective depth under soybean- chickpea cropping system. Interaction effect was also non-significant which were at par among

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themselves. The availability of copper reduces at high pH and high $CaCO_3$ content due to the formation of less soluble compounds like Cu $(OH)_2$ and $CuCO_3$. Similar results were reported by Singh *et al*., (2013).

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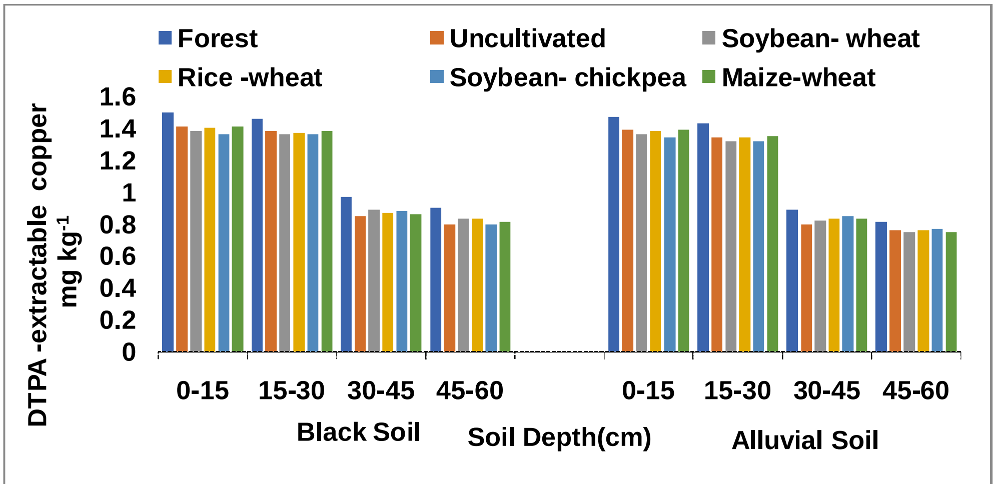

Figure 2: Effect of land use practices and soil type on DTPA-extractable copper.

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Table 2: Effect of land use practices on DTPA extractable copper in black and alluvial soils at different depths.

Soil depth (cm) Factor B (Land Uses)	DTPA Extractable Copper (mg kg^{-1})											
	0-15			15-30			30-45			45-60		
	Factor A (Soil types)											
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Forest	1.50	1.47	1.49	1.46	1.43	1.45	0.96	0.89	0.92	0.90	0.81	0.86
Uncultivated	1.41	1.39	1.40	1.38	1.34	1.36	0.92	0.87	0.90	0.83	0.76	0.80
Soybean- wheat	1.38	1.36	1.37	1.36	1.32	1.34	0.89	0.81	0.85	0.80	0.75	0.78
Rice -wheat	1.40	1.38	1.39	1.37	1.34	1.35	0.87	0.83	0.85	0.83	0.76	0.80
Soybean-Chickpea	1.36	1.34	1.35	1.36	1.32	1.34	0.83	0.79	0.81	0.80	0.75	0.78
Maize-wheat	1.41	1.39	1.40	1.38	1.35	1.37	0.85	0.85	0.85	0.81	0.77	0.79
Mean	1.41	1.39		1.38	1.35		0.89	0.84		0.83	0.77	
	A	B	A x B	A	B	A x B	A	B	A x B	A	B	A x B
SE m±	0.008	0.013	0.019	0.013	0.022	0.031	0.013	0.022	0.031	0.005	0.008	0.011
CD (p=0.05)	NS	0.039	NS	NS	0.064	NS	0.038	0.065	NS	0.013	0.023	NS

S1: Deep black soil S2 : Alluvial soil

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3.3 DTPA Extractable Iron

Data related to the DTPA extractable iron (DTPA-Fe) in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table3. Data clearly indicated that the variability in soil types was affected significantly but over the different land uses it has been non-significant. It is evident from data the DTPA extractable iron content was found higher under alluvial soil compare to black soil. It was also found that irrespective of different land uses the DTPA extractable iron decreased with depths. Data further showed that the content of DTPA extractable iron at different soil depths upto 0-60 cm varied from 8.4 to 13.2 mg kg^{-1} in black soil and 8.8 to 13.7 mg kg^{-1} in Alluvial soil. It is also evident from the data that the DTPA extractable iron (DTPA-Fe)of different land uses practices ranged from 12.2 to 13.2 at 0-15 cm, 11.8 to 12.8 at 15-30 cm, 10.1 to 10.8 at 30-45 and 8.4 to 9.2 mg kg^{-1}at 45-60 cm, respectively under black soil and 13.2 to 13.7 0-15cm, 12.6 to 13.2 15-30cm, 10.4 to 11.2 30-45 cm and 8.8 to 9.7 mg kg^{-1}45-60 cm in Alluvial soil. Numerically the maximum values of DTPA-Fe (13.2,12.8,10.8 and 9.2 mg kg^{-1}) at respective soil depths were obtained under forest soil, while minimum (12.2,11.8,10.1and 8.4 mg kg^{-1}) at 0-15, 15-30, 30-45 and 45-60 cm under rice - wheat cropping system in black soil and alluvial soil maximum values of DTPA- Fe(13.7,13.2,11.2 and 9.7 mg kg^{-1}),while minimum (13.2,12.6,10.4 and 8.8 mg kg^{-1})at respective depth under rice- wheat cropping system.Interaction effect was also non-significant which were at par among themselves. The increase in DTAP extractable micronutrients found under forest land might be due to increase in soil biodiversity, organic matter decomposition, soil porosity and soil aggregation. Somasundaram*et al.* (2013) who stated that soil organic matter increases soil micronutrients due to the chelating property of soil organic matter in holding soil micronutrients.

The available iron was found to increase with increase in CEC of soils which can be attributed to more availability of exchange sites on soil colloids Meena and Mathure (2017).With increase in organic matter in the soil there was significant increase in the availability of iron which protects the oxidation and precipitation of iron into unavailable forms.Contrary to this, availability of iron was found to be reduced with increase in pH and $CaCO_3$ contents of soils.The decreased solubility

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of iron with increase in pH is due to the formation of insoluble iron hydroxide and carbonates. Similar results have been reported by (Yadav and Meena,2009).

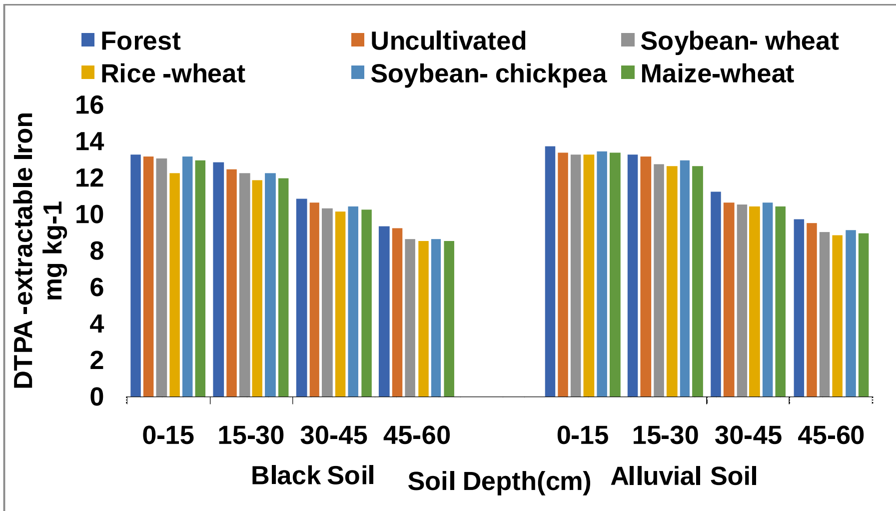

Figure 3: Effect of land use practices and soil type on DTPA-extractable Iron.

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Table 3: Effect of land use practices on DTPA extractable iron (mg kg^{-1}) in black and alluvial soils at different depths.

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Soil depth (cm) / Factor B (Land Uses)	DTPA extractable Iron (mg kg^{-1})											
	0-15			15-30			30-45			45-60		
	Factor A (Soil types)											
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Forest	13.2	13.7	13.5	12.8	13.2	13.0	10.8	11.2	11.0	9.2	9.7	9.5
Uncultivated	13.1	13.3	13.2	12.4	13.1	12.7	10.4	10.6	10.5	9.1	9.5	9.3
Soybean- wheat	13.0	13.2	13.1	12.2	12.7	12.4	10.2	10.5	10.4	8.6	9.0	8.8
Rice - wheat	12.2	13.2	12.7	11.8	12.6	12.2	10.1	10.4	10.3	8.4	8.8	8.6
Soybean- Chickpea	13.1	13.4	13.3	12.2	12.9	12.5	10.3	10.6	10.5	8.6	9.1	8.9
Maize-wheat	12.9	13.3	13.1	11.9	12.6	12.2	10.2	10.4	10.3	8.4	8.9	8.7
Mean	12.9	13.4		12.2	12.8		10.3	10.6		8.7	9.2	
	A	B	A x B	A	B	A x B	A	B	A x B	A	B	A x B
SE m±	0.14	0.24	0.34	0.21	0.37	0.52	0.10	0.17	0.23	0.14	0.25	0.35
CD (p=0.05)	0.41	NS	NS	0.62	NS	NS	0.28	NS	NS	0.42	NS	NS

S1: black soil S2: Alluvial soil

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3.4DTPA extractable manganese

Data related to the DTPA extractable manganese (DTPA-Mn) in different land use practices under two soil types at various soil depths (0-15, 15-30, 30-45 and 45-60 cm) are presented in Table 4. The results clearly indicated that DTPA extractable manganese was significantly affected by different land use practices and soil type. It is evident from data the DTPA extractable manganese content was found higher under black soil compare to alluvial soil. It was also found that irrespective of different land uses the DTPA extractable manganese decreased with depths. Data further showed that the content of DTPA extractable manganese at different soil depths upto 0-60 cm varied from 9.5 to 13.0 mg kg^{-1} in black soil and 9.2 to 12.2 mg kg^{-1} in Alluvial soil. It is also evident from the data that the DTPA extractable manganese (DTPA-Mn) of different land uses practices ranged from 12.6 to 13.0 at 0-15 cm, 12.2 to 12.6 at 15-30 cm, 10.2 to 10.7 at 30-45 and 9.5 to 10.0 mg kg^{-1}at 45-60 cm, respectively under black soil and 11.6 to 12.2 0-15cm, 10.8 to 11.3 15-30cm, 9.5 to 10.0 30-45 cm and 9.2 to 9.7 mg kg^{-1}45-60 cm in Alluvial soil. Numerically the maximum values of DTPA-Mn (13.0,12.6,10.7 and 10.0 mg kg^{-1}) at respective soil depths were obtained under forest soil, while minimum (12.6,12.2,10.2 and 9.5 mg kg^{-1}) at 0-15, 15-30, 30-45 and 45-60 cm under uncultivated land in black soil and alluvial soil maximum values of DTPA-Mn (12.2,11.3,10.0 and 9.7 mg kg^{-1}),while minimum (11.6,10.8,9.5 and 9.2 mg kg^{-1}) at respective depth under uncultivated land. Interaction effect was also non-significant which were at par among themselves. The availability of manganese on other hand was observed to be reduced significantly with an increased $CaCO_3$ content and pH. It might be due to the formation of less soluble compounds like $MnCO_3$ or $Mn(OH)_2$. The higher pH favours the formation of less soluble organic complexes of Mn, which reduces the availability of Mn and the activity of soil microorganism which oxidizes soluble Mn^{2+} (Singh *et al*., 2013).

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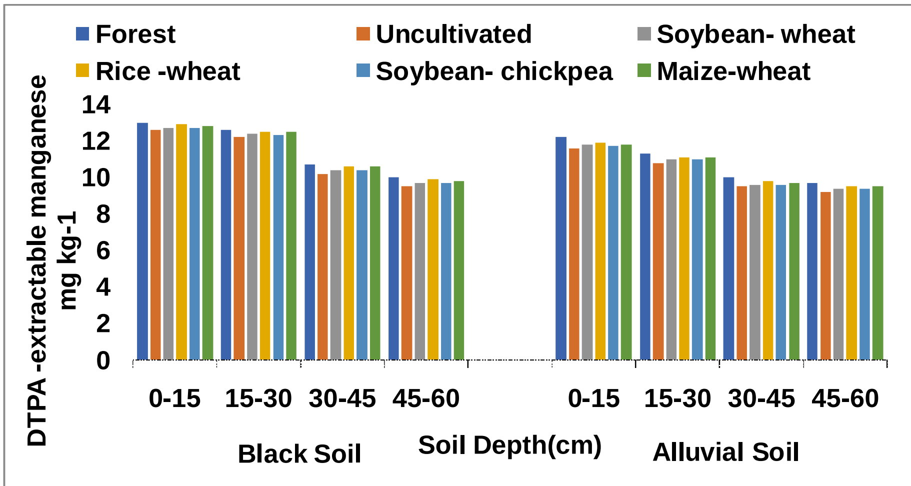

Figure 4: Effect of land use practices and soil type on DTPA-extractable manganese

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Table 4: Effect of land use practices on DTPA extractable manganese in black and alluvial soils at different depths.

Soil depth(cm) / Land Uses (B)	DTPA Extractable Manganese (mg kg^{-1})											
	0-15			15-30			30-45			45-60		
	Factor A (Soil types)											
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
Forest	13.0	12.2	12.6	12.6	11.3	11.9	10.7	10.0	10.4	10.0	9.7	9.9
Uncultivated	12.6	11.6	12.1	12.2	10.8	11.5	10.2	9.5	9.9	9.5	9.2	9.4
Soybean- wheat	12.7	11.8	12.2	12.4	11.0	11.7	10.4	9.6	10.0	9.7	9.4	9.6
Rice -wheat	12.9	11.9	12.4	12.5	11.1	11.8	10.6	9.8	10.2	9.9	9.5	9.7
Soybean-Chickpea	12.7	11.7	12.2	12.3	11.0	11.6	10.4	9.6	10.0	9.7	9.4	9.5
Maize-wheat	12.8	11.8	12.3	12.5	11.1	11.8	10.6	9.7	10.1	9.8	9.5	9.7
Mean	12.8	11.8		12.4	11.0		10.5	9.7		9.8	9.5	
	A	B	A x B	A	B	A x B	A	B	A x B	A	B	A x B
SE m±	0.06	0.11	0.16	0.02	0.03	0.04	0.02	0.03	0.05	0.01	0.01	0.02
CD (*p=0.05*)	0.19	0.33	NS	0.05	0.08	NS	0.05	0.09	NS	0.03	0.04	NS

S1: Deep black soil S2: Alluvial soil

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Table 5: Relationship among DTPA- extractable Micronutrient.

	Mn	*Cu*	*Fe*	*Zn*
Mn	1.000**			
Cu	0.916**	1.000**		
Fe	0.787**	0.884**	1.000**	
Zn	0.747**	0.706**	0.647**	1.000**

Inter-correlation studies between DTPA- extractable Micronutrient (Table 5) revealed that all micronutrient were significantly highly positive correlated to each other.

CONCLUSION

This work provides a brief information about the profile distribution of the DTPA extractable micronutrient in soils developed on black and alluvial soil in Madhya Pradesh, India. The micronutrient cations distribution in the soils does not follow any particular pattern, but varies down the profiles. The surface and sub-surface amount of the DTPA-extractable zinc (Zn^{2+}) are generally deficient in the soils for optimum crop production but extractable Fe and Cu were adequately available in the soils considered. In the present study it was found different type soils and subsequent impact on different land uses could have played an important role in distribution of sulphur and DTPA extractable micronutrient properties over a variable land uses pattern. The higher availability of these sulphur and DTPA extractable micronutrients in forest land could be attributed due to low soil pH in this land use, because forest soil had lower pH than other systems and plays an important role in controlling micronutrient availability. In forest land, high soil organic matter, minimum tillage practices and biodiversity could have contributed higher Zn and Mn content. High soil organic matter increases micronutrient availability due to the chelating mechanism. ~~further~~ Further more,a detailed study on the distribution of micronutrient in soil profile can reveals their interaction with other properties and can help for developing the needed recommendations.

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