Biological Forum – An International Journal **15(9): 325-329(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Status of DTPA- Extractable Micronutrient Cations in surface and Sub-surface Soils of different Land use System in Gwalior Chambal Division of Madhya Pradesh

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(Received: 14 June 2023; Revised: 20 July 2023; Accepted: 24 August 2023; Published: 15 September 2023)
(Published by Research Trend)

ABSTRACT: Analysis of one hundred twenty five each of surface and sub-surface soil samples from five land use system (LUS) *viz.*, Agriculture (A), Horticulture (H), Agri–horticulture (AH), Ravines (R) and Forest (F) under alluvial soils of Gwalior Chambal division of Madhya Pradesh indicate that the different land use system, maximum organic carbon content in surface and sub-surface was recorded in forest whereas minimum in ravines areas. Bulk density was decrease in natural forest and Agri-horticulture systems. DTPA extractable ZN, Fe and Mn were higher in surface soil as compared to sub surface soil in all LUS whereas Cu in some LUS. Maximum soil samples was deficient in available Zn in agriculture followed by ravines land use system whereas forest land use system show sufficient content of available zinc in surface soils. All samples of different land use system were found to be sufficient in available Cu and Mn. In case of available Fe, minimum soils samples were found deficient in forest whereas maximum in ravines area.

Keywords: Available Zn, Fe Cu and Mn. Organic carbon, bulk density, land use system.

INTRODUCTION

The dynamic nature of the soil is highly influenced by natural processes of soil formation as well as human induced. With time, soils undergo changes rapidly in their physical, chemical and biological properties due to addition of inputs such as organic manures, chemical fertilizers; pesticides and weedicides alter the soil properties. Soil nutrients are threatening agriculture potentials, because their availability depends on SOM content, soil pH, soil texture and nutrient interactions in the soil. Different land use systems influence availability of micronutrients by altering their distribution and including changes in their chemical forms by influencing soil pH organic matter, clay content and submergence (Rengel, 2007). Micronutrient plays a vital role in maintaining soil health and also productivity of crops. These are needed in very small amounts. The soil must supply micronutrients for desired growth of plants and synthesis of human food. Increased removal of micronutrients as a consequence of adoption of HYVs and intensive cropping together and only nitrogen and phosphorus fertilizers that are being used hence; attention is not given to micronutrients which are deficit in plain as well as various soils of the country. Millions of hectares of land worldwide are low in available micronutrients, and many of these deficiencies were further aggravated by the increased demands of more rapidly growing crops for available forms of micronutrients. The deficiencies of micronutrients have become major constraints to productivity, stability and sustainability of soils. Soils with finer particles and with higher organic matter can generally provide a greater reserve of these elements whereas, coarse textured soils such as, sand have fewer reserves and tend to get depleted rather quickly. The widespread need for the micronutrients observed in recent years can be accounted for in three ways *viz.*, naturally deficient in some soil types, their deficiency has been brought out by crop removal and widespread erosion together with destruction of soil organic matter has also brought about their removal from the soil. Considering all the above facts a study was made in different land use system soils of Gwalior Chambal division to know the status and theirs relationship with others soil properties.

MATERIAL AND METHODS

A total two hundred fifty (250) soil samples in which one hundred twenty five surface and same as sub-surface were collected from five land use system *viz.*, Agriculture (A), Horticulture (H), Agri–Horticulture (AH), Ravines (R) and Forest (F) under alluvial soils of Gwalior and Chambal division of Madhya Pradesh. Cultivated land under different system use for cultivation for many years and current land use system were more than ten years whereas Forest land was naturally occurred. Soils in forest and cultivated land are classified as Typic Haplaquents, and Typic Haplaquepts and Natrustalfs. Samples were processed and analyzed for physico-chemical properties by standard procedure (Jackson, 1973). For mechanical parameters Particle size (Sand, Silt & Clay) analysis was done by Bouyoucos Hydrometer method (Bouyoucos, 1952). The available micronutrients cations (Zn, Cu, Fe, and Mn) were determined by Atomic Absorption Spectrophotometer using 0.005M DTPA (Diethylene Triamine Penta Acetic Acid) as an extractant proposed by Lindsay and Norvell (1978).

RESULTS AND DISCUSSION

The important mechanical and physico-chemical parameters of the soils are presented in Table 1. The soils of different land use system was in sandy clay loam in texture and sub-surface soils show more clay content as compared to surface soil. Maximum and minimum clay content were recorded in forest and ravines land use system in both the layers. The results of increased clay particles in subsurface horizons are due to vertical movement from surface to subsurface by illuviation process. Movement and accumulation of soil was leading variation in soil properties (Moges and Holden 2008). The soils were normal to alkaline with pH ranging between 7.32 to 8.24 and 7.44 to 8.36 with an average value of 7.81 and 7.93 in surface and sub-surface soils, respectively. It is revealed from result (Table 1) that sub-surface soils show higher pH as compared to surface soil in all the land use system. The reason may be attributed to leaching of bases with percolation water and uptake by the crops and also decrease in organic matter accumulation with the depth. Besides, oxidation of ammonium to nitrate may cause the relatively lower pH of surface soil. In accordance with our results, some researchers (Khanday *et al.*, 2017; Kumar *et al.*, 2017) also found increased soil pH at higher soil depth. Electrical conductivity was 0.45 and 0.52 dSm^{-1}, in surface and sub-surface soils, characteristic of normal soils. The organic carbon was content ranging from 3.35 to 7.88 g kg^{-1} (mean 5.48 g kg^{-1}) and 3.07 to 6.55 g kg^{-1} (mean 4.67 g kg^{-1}) in surface and sub-surface soils, respectively. The organic carbon status of most of the soils was very low to medium and it decreased with the increase in soil depth which might be attributed to more addition of organic materials like stubbles, plant residues, manures etc. in top soil than subsoil. Our results are in accordance with the observations of Patangray *et al.* (2018). In case of land use system, maximum organic carbon content in both layer was recorded in forest whereas minimum in ravines areas. The high organic carbon content in forest land soil is due the luxuriant growth of grasses along with the seasonal decomposition of vegetative parts and roots. This finds support from similar observation reported by Sharma *et al.* (2006). Surface soils show more organic carbon content as compared to sub-surface soils in all the land use system. These results are in same line to those of Gupta *et al.* (2003). Under present study, higher bulk density was noted in ravines area whereas lower with forest land use system. The decrease in bulk density in natural forest and Agri-horticulture systems can be related to the effect of relatively high organic carbon content due to heavy litter fall and their subsequent decomposition in the soil layers. Karan *et al.* (1991) who reported the higher values of bulk density content in cultivated soil in comparison to grasslands or forest soils.

Table 1: Status of physico-chemical parameters of soils under different land use system.

Sr. No.	Land use system	Depth (cm)	Mechanical parameters			Physico-chemical parameters				
			Sand (%)	Silt (%)	Clay (%)	Soil pH	Electrical Conductivity (dSm^{-1})	Organic carbon (g kg^{-1})	Bulk density (Mg m^{-3})	Calcium Carbonate (%)
1.	Agriculture (A) (Rice –Wheat)	0-15 cm	56.4	16.0	27.6	7.88	0.49	4.42	1.64	1.56
		15-30 cm	54.2	17.6	28.2	7.95	0.57	4.35	1.65	2.45
2.	Horticulture (H) (Vegetables fields)	0-15 cm	51.2	20.6	28.2	7.76	0.38	4.85	1.58	1.32
		15-30 cm	48.7	22.4	28.9	7.86	0.44	4.06	1.62	1.65
3.	Forest (F) (Forest area)	0-15 cm	48.8	20.8	30.4	7.36	0.25	7.88	1.36	0.42
		15-30 cm	44.2	23.0	32.8	7.42	0.27	6.55	1.42	0.52
4.	Agri–Horticulture (AH) (Guava-Blackgram/ Greengram)	0-15 cm	52.4	25.0	22.6	7.84	0.34	6.88	1.41	1.45
		15-30 cm	47.9	23.9	28.4	7.95	0.38	5.32	1.44	1.75
5.	Ravines (R) (Fallow – Mustard)	0-15 cm	62.8	19.8	17.4	8.24	0.78	3.35	1.72	1.62
		15-30 cm	57.6	21.0	21.4	8.36	0.94	3.07	1.74	2.74
As a Whole		**0-15 cm**	**54.32**	**20.44**	**25.24**	**7.82**	**0.45**	**5.48**	**1.54**	**1.27**
		15-30 cm	**50.52**	**20.54**	**28.94**	**7.91**	**0.52**	**4.67**	**1.57**	**1.82**

Table 2: Status of available micronutrient cations (mg kg^{-1}) in different land use system.

Sr. No.	Land use system	Depth (cm)	Available Zn (mg kg^{-1})		Available Cu (mg kg^{-1})		Available Fe (mg kg^{-1})		Available Mn (mg kg^{-1})	
			Range	Mean	Range	Mean	Range	Mean	Range	Mean
1.	**Agriculture (A)** (Rice – Wheat)	0-15 cm	0.38 – 1.48	0.72	1.14 – 8.44	3.56	2.88 – 12.04	7.26	3.22 -15.66	5.26
		15-30 cm	0.24 – 1.06	0.44	0.98 – 6.12	3.04	1.32 – 8.64	4.88	2.18 -10.68	4.14
2.	**Horticulture (H)** (Vegetables fields)	0-15 cm	0.44 – 2.02	0.94	0.84 – 10.06	3.88	4.02 – 18.32	11.28	4.12 – 19.36	7.69
		15-30 cm	0.36 – 0.74	0.62	1.22 – 11.60	4.12	2.66 – 14.02	8.32	2.88 -15.02	6.28
3.	**Forest (F)** (Forest area)	0-15 cm	0.84 – 3.18	1.08	2.72 – 11.26	5.88	7.22 – 28.64	14.26	7.32 – 34.36	16.98
		15-30 cm	0.52 – 2.76	0.82	3.26 – 14.22	6.32	5.44 – 18.98	11.24	3.66 – 21.30	11.26
4.	**Agri–Horticulture (AH) (**Guava-Blackgram/ Greengram)	0-15 cm	0.48 – 1.68	0.88	2.66 – 6.48	4.15	3.42 – 17.68	10.65	5.35 – 24.26	11.02
		15-30 cm	0.32 – 1.12	0.52	3.06 – 7.24	6.08	2.44 – 16.48	8.08	2.94 – 12.36	5.62
5.	**Ravines (R)** (Fallow – Mustard)	0-15 cm	0.22 -1.06	0.68	1.08 – 4.24	2.18	2.08 – 13.20	6.44	2.48 - 7.36	3.66
		15-30 cm	0.14 – 0.88	0.42	0.84 – 2.46	1.40	1.72 – 8.26	4.69	1.08 – 4.62	2.18
As a Whole		**0-15 cm**	**0.22 – 3.18**	**0.86**	**1.08 – 11.26**	**3.93**	**2.08 – 28.64**	**9.98**	**2.48 – 34.36**	**8.92**
		15-30 cm	**0.14 – 2.76**	**0.56**	**0.84 – 14.22**	**4.19**	**1.72 – 18.98**	**7.44**	**1.08 – 21.30**	**5.90**

Available micronutrient cations. Status of DTPA extractable micronutrient cations under different land use system are presented in Table 2.

Available Zn. Under different land use system, available Zn was observed in the range of 0.22 to 3.18 and 0.14 – 2.76 mg kg^{-1} with the average value of 0.86 and 0.56 mg kg^{-1} in surface and subsurface soils respectively. It is clear from result (Table 2) that surface soils contained more values of available Zn in all the land use system as compared to sub surface soils. The soils under forest land use system contained relatively higher content of available zinc followed by horticulture field and minimum under ravines land use system in both the surface. Consider the critical limit of DTPA – Zn (<0.6 mg kg^{-1}) as suggested by Bansal and Takkar (1986). Among total surface soil samples (125) of all land use system, 36.8% samples were found to be deficient in DTPA-Zn. Singh *et al.* (2014); Rajput *et al.* (2015) also reported that the available Zn was deficient in 64.5 and 46.0% soils samples in Chambal region and northern Madhya Pradesh. In case of land use system, maximum soil samples (18 out of 25) was deficient in agriculture followed by ravines land use system (14 out of 25) whereas minimum or nil (0 out of 25) was under forest land use system (Table 3). This finds support from similar observation reported by Panwar *et al.* (2011).

DTPA extractable Zn showed a highly significant and positive correlation (0.678**) with organic carbon content of the soils. This clearly indicates that organic carbon content increases the availability of Zn. A large number of studies have showed highly significant linear positive relationship between these two parameter. This finds support from similar relationship reported by Singh and Rao (2001); Sharma *et al.* (2004). In the present investigation, the available Zn showed negative correlation with pH, because, in calcareous and alkaline soils, Zn adsorption by CO_3^{--}, precipitations of Zn carbonates or formation of insoluble calcium zinc at are partially responsible for lower Zn availability. This finds support from similar observation reported by Yadav and Meena (2009); Rajput *et al.* (2015).

Table 3: Categories of micro-nutrients in surface soils of different land use system.

Land use system	No. of samples analysed	Micronutrients (mg kg^{-1})							
		Zn		Cu		Fe		Mn	
		Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient	Deficient	Sufficient
Agriculture (A) (Rice –Wheat)	25	18 (72.0)	07 (28.0)	0 (0.0)	25 (100)	04 (16.0)	21 (84.0)	0 (0.0)	25 (100.0)
Horticulture (H) **(Vegetables fields)**	25	06 (24.0)	19 (76.0)	0 (0.0)	25 (100.0)	03 (12.0)	22 (88.0)	0 (0.0)	25 (100.0)
Forest (F) (Tapowan Forest area)	25	00 (0.0)	25 (100.0)	0 (0.0)	25 (100.0)	0 (0.0)	25 (100.0)	0 (0.0)	25 (100.0)
Agri–Horticulture (AH) (Guava-Blackgram/ Greengram)	25	08 (32.0)	17 (68.0)	0 (0.0)	25 (100.0)	02 (8.0)	23 (92.0)	0 (0.0)	25 (100.0)
Ravines (R) (Fallow – Mustard)	25	14 (56.0)	11 (44.0)	0 (0.0)	25 (100.0)	06 (24.0)	19 (76.0)	0 (10.0)	25 (90.0)
Whole land use system	**125**	**46 (36.8)**	**79 (63.2)**	**0 (0.0)**	**125 (100.0)**	**15 (12.0)**	**110 (88.0)**	**00 (0.0)**	**125 (100.0)**

Table 4: Correlation matrix between available micronutrient cations and soil properties.

Micronutrient cation	Soil properties						
	Sand	Silt	Clay	pH	E C	Organic carbon	$CaCO_3$
Zn	-0.602**	0.255	0.528**	-0.598**	0.106	0.678**	-0.389*
Cu	-0.115	0.318*	0.426*	- 0.463**	-0.045	0.544**	-0.468**
Fe	-0.486**	0.127	0.403*	-0.432*	-0.164	0.617**	-0.455*
Mn	-0.412*	0.118	0.618**	-0.647**	0.048	0.586**	-0.632**

* Significant at 5% level   ** Significant at 1% level

Available Cu. The DTPA - extractable Cu content in the soils of different land use system varied 1.08 to 11.26 and 0.84 to 14.22 mg kg^{-1} with the average value of 3.93 and 4.19 mg kg^{-1} in surface and subsurface soils respectively. It is revealed from result (Table 2) that sub-surface soils contained more values of available Cu in all the land use system as compared to surface soils except agriculture and ravines. The soils of forest land use system contained relatively higher content of available Cu whereas minimum under ravines land use system in both the surface. Consider the critical limit of DTPA –Cu (<0.2 mg kg^{-1}) as suggested by Bansal and Takkar (1986). Among total surface soil samples (125) of all land use system, all samples were found to be sufficient in available Cu. DTPA extractable Cu showed a highly significant and positive correlation with organic carbon content of the soils. This may be attributed to increased stability of Cu complexes implicating presence of greater amount of DTPA-Cu bound with organic matter. These observations confirmed those made by Rajput *et al.* (2015).

Available Fe. Status of available - Fe under different land use system are presented in Table 2. It is observed in the range of 2.08 to 28.64 and 1.72 to 18.98 mg kg^{-1} with the average value of 9.98 and 7.44 mg kg^{-1} in surface and subsurface soils respectively. It is clear from result (Table 2) that surface soils contained higher content of available Fe in all the land use system as compared to sub surface soils. In case of land use system, the soils under forest land contained relatively higher content of available Fe and minimum under ravines land use system in both the surface. Consider the critical limit of DTPA- Fe (< 4.5 mg kg^{-1}) as suggested by Bansal and Takkar (1986). Among total surface soil samples (125) of all land use system, 12.0% samples were found to be deficient in DTPA-Fe. This finds support from similar observation reported by Singh *et al.* (2014). In case of land use system, minimum soils samples were found deficient in forest whereas maximum in ravines area. DTPA extractable Fe showed a highly significant and positive correlation with organic carbon content of the soils. Organic matter may hasten soil reduction, cause more CO_2 production and therefore bring about faster and greater accumulations of available Fe. This is substantiated by the significant positive correlation between available Fe and organic carbon in the soils under present study. Sharma *et al.* (2003); Yadav and Meena (2009) also reported significant and positive relationship between available Fe and organic carbon.

Available Mn. The available Mn content in different land use system ranged from 2.48 to 34.36 and 1.08 to 21.30 with the average value of 8.92 and 5.90 mg kg^{-1} in surface and subsurface soils respectively. It is clear from result (Table 2) that surface soils contained more values of available Mn in all the land use system as compared to sub surface soils. In case of land use system, maximum and minimum content of available Mn was noted under forest and ravines land use system in both the surface. Consider the critical limit of DTPA – Mn (<1.0 mg kg^{-1}) as suggested by Bansal and Takkar (1986). Among surface soil samples (125) of all land use system, 100% samples were found to be sufficient in DTPA-Mn. This finds support from similar observation reported by Pachauri and Trivedi (2011). Significantly positive relationship between available Mn and organic carbon was found in the soils under study. It is thus apparent that the availability of Mn increased with increasing organic matter content in the soils. Which may be due to either its addition to the soil through plant residues or because the decomposing organic matter promotes its extraction or both**.** This finds support from similar observation reported by Singh and Rao (2001) and Sharma *et al.* (2003).

CONCLUSIONS

The present study revealed a picture on the influence of different land use systems (LUS) on the available micronutrient cations status and physico-chemical properties of the soils of Gwalior Chambal region of Madhya Pradesh. It has been observed that forest and agri-horticulture land exhibited better status in most of the micronutrient status as well as soil parameters than the other land use system. The mean bulk density values of the studied soils were found higher in uncultivated LUS indicated more soil compaction in uncultivated LUS resulting unfavorable soil condition. Considering the forest land as benchmark, the inferiority of soils under agricultural activity is visible in the present investigation. Thus, initiation of judicious and location specific soil management practices becomes an important step in order to maintain the soil health in a sustainable basis.

Acknowledgement. I express my deep and sincere regards, profound sense of gratitude and indebtedness to my parents and Dr. S. K. Trivedi, Chairman of my Advisory Committee, Professor and Head, Department of Soil science for untiring supervision, meticulous guidance and benevolent criticisms during the entire course of this investigation. And I also want to thanks my friends, seniors and juniors.

Conflict of Interest. None.

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How to cite this article: Rajput B.K., Trivedi S. K., Sharma S.K. and Yadav S.S. (2023). Status of DTPA- Extractable Micronutrient Cations in surface and Sub-surface Soils of different Land use System in Gwalior Chambal Division of Madhya Pradesh. *Biological Forum – An International Journal, 15*(9): 325-329.