Vertical distribution of micronutrient cations in a basaltic terrain of Rajasthan in relation to soil properties

S.S. SHARMA, K.L. TOTAWAT[1] AND R.L. SHYAMPURA

National Bureau of Soil Survey and Land Use Planning Regional Centre, Udaipur 313 001, India

Abstract : Five representative soil profiles from five distinct physiographic units of the basaltic terrain of southern Rajasthan were studied for the DTPA extractable Zn, Cu, Fe and Mn in relation to some important soil properties. Soils at the higher elevation contained more micronutrient cations than the soils at the lower elevation. The soils of the study area were adequate in DTPA-extractable micronutrient cations and had significant negative correlation with pH and $CaCO_3$.

Additional Key Words *: Basaltic terrain, physiography, critical limit.*

Introduction

The land to man ratio is narrowing rapidly and there is no scope for horizontal expansion. The future requirement has to be met through vertical growth and intensification of agriculture. Micronutrients have an important role in stabilization of crop yield of an area. Information on the content and distribution of micronutrients in the soils of various landforms of the basaltic terrain of Rajasthan (Chattopadhyay *et al.* 1996) is scanty. The soils of this region have developed mainly from weathered basalt and occur on various types of landforms. The soils are shallow to deep, loamy to clayey in texture and are potential zone for producing agricultural crops. Therefore, an attempt has been made to assess the available status of micronutrients and their relationship with different properties of soils in five pedons from five various landform units of basaltic terrain occurring in Pratapgarh region of southern Rajasthan as available informations are scanty and scattered.

Materials and methods

In the study area, five physiographic units, *viz,* hills, plateau, gently sloping plain, levelled plain and dissected plain (Table1) were identified and five representative soils were studied for their morphometric characteristics (Soil Survey Division Staff 1995). Soil samples (horizon - wise) were collected for laboratory analysis following standard methods. The DTPA - extractable micronutrient cations of the soils were determined as per the method described by Lindsay and Norvell (1978) and analysed on AAS.

Results and Discussion

Soil characteristics

Soils at the higher elevation (hills and plateau) were neutral in reaction as compared to those located in plains (Table 2). Higher pH values (7.7 to 8.4) coupled with relatively higher content of $CaCO_3$ in the soils of plains is probably due to migration of bases from higher to lower elevation (Duchaufour1982). The soils of hill, plateau and gently sloping plain are in general, low in $CaCO_3$ (4.1 to 8.5 %), while, higher value of $CaCO_3$ content (29.4 to 36.2 %) was observed in dissected alluvial plain (P5). The high $CaCO_3$ content at the lowest elevation of the transect may be ascribed partly due to transportation of $CaCO_3$ from higher reaches (Sharma *et.al.*

Department of Agricultural Chemistry and Soil Science, Mahatma Pratap University of Agriculture and Technology, Udaipur, 313001 India

Table 1: Site characteristics

Location	Taxonomy	Elevation above msl (m)	Physiographic Unit	Land use
Mauri khera	Clayey-skeletal, mixed, hyperthermic Lithic Ustorthents	542	Steeply sloping hill	Barren
Devgarh	Clayey-skeletal, mixed, hyperthermic Typic Ustorthents	525	Gently sloping undulating Malwa plateau	Pasture
Panmori	Fine, smectitic hyperthermic Typic Haplusterts	515	Gently sloping plain	Double cropping
Amlavad	Fine, smectitic hyperthermic, Typic Haplusterts	510	Nearly levelled alluvial plain	Double cropping
Thara	Fine-loamy, mixed, hyperthermic Typic Ustifluvents	480	Gently sloping dissected alluvial plain	Cultivated/and or grazing

1996). Further, in general, all the landforms exhibited an increase in $CaCO_3$ with depth due to the process of leaching of Ca and subsequent precipitation as carbonate at lower depths (Singh *et. al.* 1999). The soils were non-saline in nature with an organic carbon content ranging from 0.32 to 0.90 per cent.

DTPA extractable micronutrients

The content of Zn ranged between 2.8 to 3.2 mg kg^{-1} in hills and in rest of the landforms it ranged between 0.5 to 1.6 mg kg^{-1} (Table 2). The DTPA-Cu content of the soils varied widely and ranged between 1.9 to 2.3 mg kg^{-1} in hill and plateau. In plains, it varied from 0.50 to 1.51 mg kg^{-1}. The content of Zn and Cu were, in general, higher in the surface layers and decreased with depth. Neutral pH (6.5 to 7.3) of the hill and plateau soils may be the reason for enrichment of Zn and Cu as compared to the soils of plains, where the soils were more alkaline and calcareous in nature.This could be attributed to the formation of insoluble hydroxy complexes of Zn and Cu in alkaline conditions (Menzel and Jackson 1950). Similarly, while working on micronutrient mechanism in soils, several workers reported that in presence of soluble and insoluble carbonates, the formation of basic carbonate of Cu and Zn may take place (Menzel and Jackson 1950; Cavallaro and Mc Bride1978 and Chattopadhyay *et.al.* 1996).

Simple correlation studies showed that the DTPA-extractable Zn was significantly and negatively correlated with pH(r = 0.86) and $CaCO_3$ (r = -0.41), while, DTPA-Cu was significantly and negatively correlated with pH (r = 0.87). These finding were in agreement with the findings of Sakal *et al.* (1988) and Chattopadhyay *et al.* (1996). At higher pH both Fe and Mn form insoluble hydroxides due to the oxidation of the divalent cations to higher valent forms which are relatively less soluble. This might be the key factor for the lower content of Fe and Mn in the soils of plains which ranged from 8.0 to 11.7 mg kg^{-1} and 4.5 to 12.8 mg kg^{-1}, respectively as compared to their content in the soils of higher elevation (13.5 to 18.7 mg kg^{-1} and 16.8 to 21.9 mg kg^{-1}) for Fe and Mn, respectively. The Fe and Mn content showed a higher value in the surface layers in all the pedons which could be ascribed to higher biological activity in surface soil (Murthy *et.al.* 1997; Jagdish Prasad and Gajbhiye 1999). Simple correlation studies also indicated a significant and negative correlation of Fe with pH (r = 0.94) and $CaCO_3$ (r = 0.43). Likewise, Mn also showed a significant and negative correlation with pH (r = 0.95) and $CaCO_3$ (r = 0.59). These results are in conformity with the findings of Sakal *et.al.* (1988) and Vijay Kumar *et.al.* (1996).

The soils of Pratapgarh region are adequate in all the four available micronutrient cations as per the threshold values of 4.5 mg kg^{-1} for Fe (Linsay and Norvell 1978); 0.6 mg kg^{-1} for Zn (Katyal 1985), 3.0 mg kg^{-1} for Mn (Shukla and Gupta 1975) and 0.2 mg kg^{-1} for Cu (Katyal and Randhawa 1983). In general, soils of the hills and plateau were higher in available micronutrients as compared to the soils of the plains.

Table 2: Characteristics of soils

Depth	Horizon	pH	EC	O.C.	$CaCO_3$	DTPA extractable (mg kg^{-1})			
			(dS m^{-1})	(%)		Cu	Zn	Fe	Mn
				P1: Steeply sloping hill					
0-17	A1	6.5	0.19	0.90	4.5	2.3	3.2	18.7	21.9
17-35	AC	6.6	0.18	0.84	4.7	2.0	2.8	18.0	21.2
35+	Cr								
				P2: Gently sloping undulating Malwa plateau					
0-23	A1	7.1	0.25	0.75	4.5	2.0	1.6	15.7	18.5
23-40	AC	7.3	0.14	0.72	4.8	1.9	1.4	13.5	16.8
40-60+	Cr								
				P3: Gently sloping plain					
0-19	Ap	7.7	0.28	0.63	4.7	1.51	1.39	11.78	12.8
19-40	Bw	7.9	0.18	0.56	4.8	1.41	1.34	10.34	12.1
40-56	Bss1	8.0	0.18	0.46	8.5	1.44	1.34	9.66	11.2
56-80	Bss2	8.3	0.16	0.44	4.1	1.40	1.29	9.60	11.0
80+	R								
				P4: Nearly levelled alluvial plain					
0-12	Ap	8.2	0.20	0.60	9.2	0.79	1.42	10.5	11.26
12-40	Bw	8.3	0.13	0.33	9.2	0.78	1.17	10.3	10.58
40-56	Bss1	8.3	0.14	0.33	9.5	0.71	1.19	10.4	9.26
56-77	Bss2	8.4	0.14	0.32	9.9	0.78	1.19	9.0	8.20
77-100	Bss3	8.4	0.14	0.32	9.5	0.63	1.11	10.4	7.3
100-125	BC	8.3	0.16	0.33	9.5	0.54	1.11	9.7	7.5
125-140	2Cr	8.3	0.20	0.26	8.5	0.50	1.00	8.2	5.5
				P5: Dissected alluvial plain					
0-19	Apk	8.3	0.46	0.51	29.4	1.3	1.5	11.5	8.2
19-37	2ACk	8.4	0.18	0.33	29.4	1.1	1.3	10.5	7.3
37-50	2Ck1	8.4	0.18	0.35	32.1	1.0	1.0	8.0	6.9
50-71	2Ck2	8.4	0.18	0.33	36.2	1.0	0.5	8.0	4.5

Table 3: Correlation coefficient (r) between soil properties and available micronutrients

Soil property	DTPA extractable			
	Zn	Cu	Fe	Mn
pH	-0.86*	-0.87*	-0.94*	-0.95*
EC	0.11	0.22	0.14	0.01
OC	0.82	0.90	0.90	0.94
$CaCO_3$	-0.41*	-0.29	-0.43*	- 0.59*

* significant at 5%

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