academicJournals

Vol. 8(41), pp. 5096-5103, 24 October, 2013
DOI: 10.5897/AJAR2013.7168
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Available nutrient status and their relationship with soil properties of Aravalli mountain ranges and Malwa Plateau of Pratapgarh, Rajasthan, India

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Accepted 24 June, 2013

The present study was conducted to study the available nutrient status and their relationship with soil properties. In the present investigation, two transects, that is, Aravalli mountain ranges and Malwa plateau, were selected in the pratapgarh district having eight landforms namely hill, pediments, valley, and plain in the Aravalli Mountain ranges and Malwa plateau, respectively. Total eight pedons were examined in the field and investigated in the laboratory using standard laboratory procedures. The soils of all pedons were found deficient in available nitrogen and phosphorus while adequate in available potassium. The diethylenetriaminepentaacetic acid (DTPA) extractable micronutrients like iron, manganese and copper were found sufficient and zinc was deficient in soils of both transect. Major and micronutrients were found relatively higher in soils of Malwa plateau compared to soils of Aravali mountain ranges.

Key words: Major and micro nutrient status, mechanical, physico-chemical, soil.

INTRODUCTION

Pratapgarh is newest constituted district of Rajasthan state, which is a tribal dominant with an area of 411736 ha. Pratapgarh is situated in the southern part of Rajasthan. The area adjoins Udaipur and Bhilwara district of Rajasthan and Mandsaur district of Madhya Pradesh state. It is the part of Udaipur division and has been curved out from the erstwhile tehsils of Chitorgarh, Udaipur and Banswara districts. It is situated on the junction of Aravali mountain ranges and the Malwa Plateau; hence characteristics of both are prominent in the area. Pratapgarh is located at 29.03° North and 74.78° East. It has an average elevation of 491 m (1610 feet). It is the highest place in Rajasthan after Mount Abu. The district has a peculiar configuration. It has two portions, somewhat separated from each other .The topography of the district is generally undulating but there are hills scattered all over the area. The hills rise up to 617 m and belong to the famous Aravalli ranges. The western, southern and northern parts of the district are somewhat plains. North and southern part of the district have black cotton soil in abudance. The major irrigation project of the district is the Jakham Dam. The north-west part of this region had dense forests. The thickly wooded Sita Mata Wildlife Sanctuary sprawls over the Aravalli ranges and the Malwa plateau, with three seasonal rivers flowing through the forest (Figure 1).

MATERIALS AND METHODS

Available nitrogen determination was carried out using the permanganate reduced method described by Subbiah and Asija (1956). The assessment of available phosphorus by using 0.5 M

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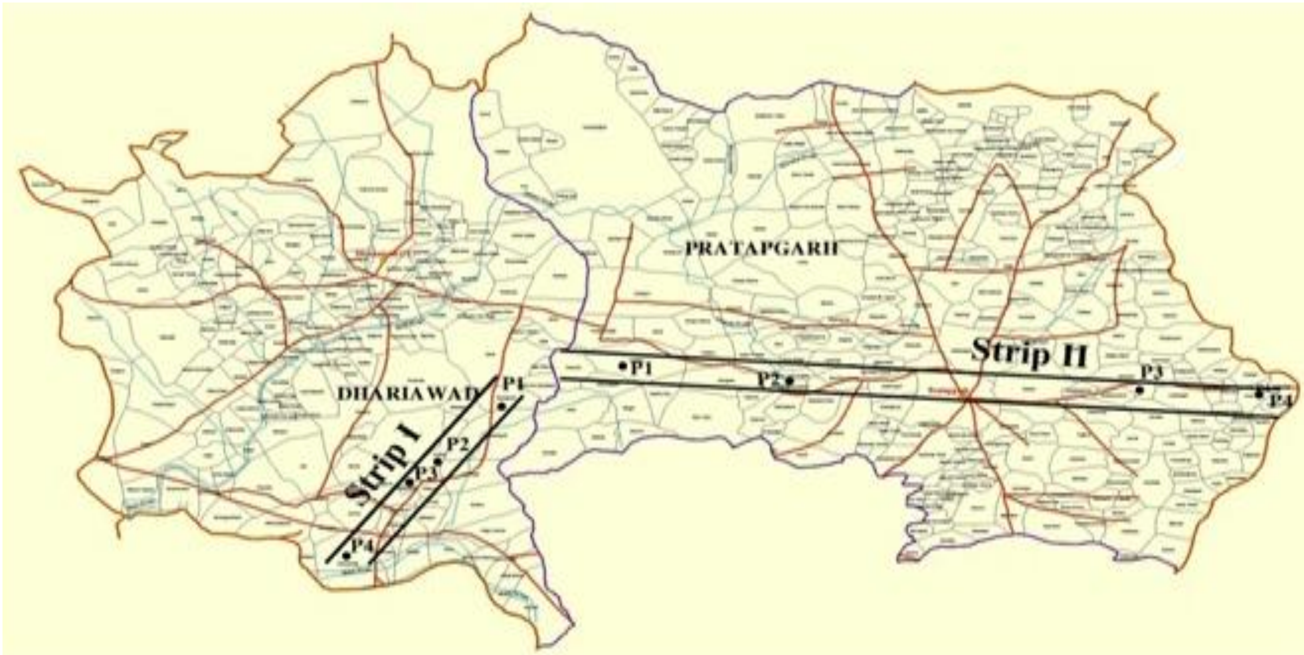

Strip I Aravali mountain ranges	SRM unit	Strip II Malwa plateau	SRM unit
P1 Dipora	172	P5 Chiklad	318
P2 Lodiya	193	P6 Shahjikapathar	330
P3 Bhagadera	239	P7 Ghotarsi	324
P4 Charpotiya	229	P8 Kuni	337

Figure 1. Site for profile examination and sampling in aravali mountain ranges and malwa plateau.

$NaHCO_3$ extract as described by Olsen et al. (1954). Whereas, available potassium was estimated by 1 N NH_4 OAC (pH 7.0) extract method and determined by flame photometer as per Hanway and Heidal (1952) method. Available micronutrients were assessed by using diethylenetriaminepentaacetic acid (DTPA) extractable method as described by Lindsay and Norvell (1978).

Statistical analysis

The relationship between different soil characteristic and nutrient contents in soils was determined by using standard statistical methods. The coefficient was determined by using the formula:

$$r = \sqrt{\frac{SP\ (xy)}{SS\ (x),\ SS\ (y)}}$$

Where, r = correlation coefficient; SP (xy) = sum product of x, y variables; SS (x) = sum of square of x variable, and SS (y) = sum of square of y variable

RESULTS AND DISCUSSION

Available nitrogen

Nitrogen is the most important major nutrient required by plant for proper growth and development and it is a part of all living cells and is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy. The data pertaining to available nitrogen contents are presented in Table 1. The values ranged between 86.0 to 186.0 kg ha^{-1} with a mean value of 142.23 kg ha^{-1} in soils of Aravali mountain ranges. Considering the available nitrogen rating values, that is low (<272 kg ha^{-1}), medium (272 to 544 kg ha^{-1}) and high (>544 kg ha^{-1}) as suggested by Arora (2002), it was observed that all pedons soil were found low in available nitrogen. In soils of Malwa plateau, the content of available nitrogen ranged between 90.0 to 253.0 kg ha^{-1} with mean value 161.63 kg ha^{-1}. An examination of data with respect to available nitrogen in the Table 1 reveals that the content of available nitrogen decreased with a subsequent increase in the depth of the profile in all the pedons of both transect. Further, a critical examination of data of organic carbon content and available nitrogen content (Table 1) indicated that there was a relationship between organic carbon and available nitrogen in all the pedon of both transect.

A thorough examination (Table 1) revealed a significant and negative correlation with clay (r = -0.964**) and silt (r = -0.539*), negative non significant (r = -0.482) with pH, negative significant (r = -0.785**) with CEC and available nitrogen content in the soils of Aravali mountain ranges while in case of soils of Malwa plateau it was observed that available nitrogen content positive non significant (0.414) with silt, non-significant and negatively correlated with clay (r = -0.238), pH (r = -0.254), CEC (r = -0.336) (Table 2a and b). Whereas a highly significant and positive correlation (r = 0.81** and r = 0.870**) was pointed out between organic carbon and nitrogen in both transects soils, respectively.

At the elevated topography, presences vegetation has in turn resulted in a higher organic carbon content of the soil and thereby a comparatively higher status of available nitrogen in pedon P_2, P_6, and P_7. At the lower topography, the soils were subjected to intensive cultivation, encouraging the oxidation of organic carbon. Higher amount of nitrogen at elevated topography have also been reported by Biddappa and Venkata Rao (1973) and Minhas and Bora (1982). Similarly, Rathore (1993), Sharma (1994), Yeresheemi et al. (1997) and Sharma (2000) observed a decrease in available nitrogen content with an increase in the depth of profile.

Available phosphorus

Phosphorus is the second most important major nutrient required by plants after nitrogen for proper growth and development and like nitrogen, phosphorus (P) is also an essential part of the process of photosynthesis, involved in the formation of all oils, sugars, starches etc. A perusal of data on available phosphorus presented in Table 1 shows the content to ranged between 3.30 to 11.31 kg ha^{-1} with a mean value of 6.29 kg ha^{-1} in various profiles in Aravali mountain ranges. Considering the available phosphorus rating values, that is, low (<12.40 kg ha^{-1}), medium (12.40 to 22.40 kg ha^{-1}) and high (>22.40 kg ha^{-1}) as suggested by Arora (2002) it was observed that all pedons soil of Aravali mountain ranges were found low in available phosphorus. However, maximum content of available phosphorous was observed in soils of hill top (P_1) followed by valley (P3) whereas lowest value was observed in soils of pediments and plain (P_2 and P_4). In soils of Malwa plateau, the content of available phosphorus ranged between 7.20 and 20.90 kg ha^{-1} with mean value 13.43 kg ha^{-1}. Only the soils of pediment (P_6) valley (P_7) were found medium in available phosphorous and remaining pedons soil (P_5 and P_8) were observed low in available phosphorous content. The low available phosphorous content of both transect soils might be due to fixation of available phosphorous by free oxides and exchangeable aluminium. Relatively higher phosphorus content in Malwa plateau soils could be due to presence of greater quantity of P bearing rock material as compared to Aravali mountain ranges. A gradual decrease of phosphorus was noted down the depth in all pedons except pedon P_7 where increasing distribution of P throughout whole profile was noted. The available phosphorus content of the soil was in general higher in higher topographic position as compared to soils occurring on lower topographic position in both the transects (Table 1). The variation in phosphorus content may be attributed to more vegetative cover which resulted high organic matter in pedon positioned at higher elevation. The low content of available phosphorous in lower topographic position pedons could also be ascribed to the high amount of free oxides of Ca^{2+}, $Mg^{2+}$and Na^{+} which induce the fixation and subsequent precipitation of phosphorus as well as to the low amount of organic matter. The significant and negative correlation with clay (r = -0.608*), silt (r = -0.571*) and CEC (r = -0.627*) pointed out that there was negative impact of topography on available phosphorus and with organic carbon (r=0.678**) there was significant and positive correlation pointed out. While in the case of Malwa plateau soils it was observed that non-significant and positive correlation with silt (r = 0.202), clay (r = 0.112), O.C. (r = 0.315) and CEC (r = 0.008) and negative significant relation pointed out with pH (r = -608*). Gaikwad et al. (1974) and Sharma (1994) have also reported similar results with respect to available phosphorus content.

Available potassium

Potassium is absorbed by plants in larger amounts than any other mineral element except nitrogen and, in some cases, calcium. The available potassium content in various landforms (Table 1) ranged between 123.0 and 420.0 kg ha^{-1} with a mean value 229.84 kg ha^{-1} in soils of Aravali mountain ranges. Considering the available potassium rating values, that is, low (<113 kg ha^{-1}), medium (113 to 280 kg ha^{-1}) and high (>280 kg ha^{-1}) as suggested by Arora (2002), it was observed that hill top (P_1) and valley (P_3) pedons soil were found medium in available potassium except soils of pediment pedon (P_2) and plain (P_4) which were found high in available potassium content. The minimum content of available potassium was observed in soils of valley (P_3). While in soils of Malwa plateau, the content of available potassium ranged between 70.0 and 520.0 kg ha^{-1} with a mean value 241.7 kg ha-^{1}. It was observed that soils of pediment (P_6) and plain and (P_8) pedons were found under high available potassium category while the soils of valley (P_7) were found medium in available potassium and soils of hill top (P_5) were low in available potassium content. A critical examination of the data reveals that the content of available potassium was found to be higher in surface soils as compared to subsurface soils of all the pedons of both transects, except pedon P_6 and P_8 may be due to higher organic carbon content as well as due to addition of potassium bearing fertilizers in surface horizons. Similar results were observed by Pal and Singh (1993). The relative immobility of this element on account

Table 1. Available major and micronutrients.

Pedons	Horizon designation	Major nutrients (kg ha^{-1})			Micro nutrients (mg kg^{-1})			
		N	P	K	Fe	Mn	Zn	Cu
Aravali mountain ranges								
Hills (Dipora)								
P_1	Al	170	15.31	181	6.11	8.10	0.29	0.89
Pediments (Lodiya)								
P_2	A	186	3.31	331	4.61	4.00	0.09	0.60
	C	176	3.30	300	4.56	3.21	0.04	0.56
	Wt. mean	180.00	3.30	312.40	4.58	3.53	0.06	0.58
Valley (Bhagadera)								
P_3	Ap	180	7.87	157	09.41	10.88	0.32	0.24
	A2	118	7.55	145	5.17	12.24	0.24	0.59
	Bw1	97	7.57	140	4.87	8.88	0.27	0.14
	C	105	4.88	123	4.96	9.28	0.24	0.15
	Wt. mean	120.96	6.66	138.35	5.87	10.14	0.26	0.26
Plain (Charpotiya)								
P_4	AP	128	4.52	420	8.10	4.66	0.66	0.40
	Bw1	102	4.45	195	9.48	4.14	0.24	0.38
	Bss1	98	3.95	255	9.12	2.66	0.23	0.35
	Bss2	90	3.55	235	9.90	2.36	0.21	0.40
	Bss3	88	3.55	288	10.04	2.57	0.20	0.48
	Ck	86	3.55	285	8.02	1.10	0.28	0.30
	Wt. mean	97.97	3.89	287.64	9.04	2.78	0.31	0.38
Malwa plateau								
Hills (Chiklad)								
P_5	Ap	146	11.15	98	11.44	22.60	1.05	1.09
	C	129	7.20	70	10.85	17.84	1.35	1.15
	Wt. mean	135.38	8.68	80.50	11.07	19.63	1.24	1.13
Pediments (Shah ji ka pathar)								
P_6	Ap	190.00	20.90	341	14.20	35.90	2.19	0.90
	Al	178.34	12.46	348	11.08	36.84	0.66	0.80
	C	161.92	12.32	331	12.80	37.62	1.75	1.05
	Wt. mean	175.97	15.44	338.68	12.89	36.81	1.65	0.94
Valley (Ghotarsi)								
P_7	Ap	253	14.86	266	7.98	4.46	0.49	0.56
	Bw1	225	13.65	176	8.44	3.89	0.48	1.08
	Bw2	185	15.75	158	7.70	2.95	0.45	1.12
	Bw3	165	16.85	149	5.86	5.75	0.42	0.48
	Wt. mean	195.45	15.63	174.31	7.10	4.61	0.45	0.75
Plain (Kuni)								
P_8	Ap	248	18.67	520	10.00	2.55	1.05	1.05
	Bss1	136	13.66	329	10.76	1.56	0.08	0.66
	Bss2	174	13.60	333	09.85	1.32	0.04	0.64
	Bss3	92	13.59	318	09.95	1.05	0.15	0.64
	C	90	12.58	415	6.88	0.55	0.69	0.62
	Wt. mean	139.75	13.99	373.31	9.32	1.28	0.36	0.69

of fixation with clay could also another reason for this. It can be further seen from the Table 1 that content of available potassium increase down the slope from hill top to nearly level plain. Whereas in pedons P_4 and P_8 an abrupt fall down the depth in available potassium content was recorded in soils of Aravali mountain ranges and

Table 2a. Correlation matrix for the physico-chemical properties of Malwa transect soils.

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	FS+VFS	Silt	Clay	pH	OC	CEC	0.03Mr	1.5Mr	Avail N	Avail P	Avail K	Avail Fe	Avail Mn	Avail Zn	Avail Cu	$CaCO_3$	SiO_2	Al_2O_3	Fe_2O_3	MnO_2	Value	chroma
1	1.000**																					
2	-0.805**	1.000**																				
3	-0.645**	0.297	1.000**																			
4	0.184	0.273	0.787**	1.000**																		
5	-0.142	0.418	-0.342	-0.435	1.000**																	
6	-0.537*	0.153	0.971**	0.201	-0.426	1.000**																
7	-0.919**	0.611*	0.747**	-0.078	-0.063	0.686**	1.000**															
8	-0.875**	0.591*	0.815**	0.184	-0.080	0.752**	0.926**	1.000**														
9	-0.113	0.414	-0.238	-0.254	0.819**	-0.336	-0.380	-0.346	1.000**													
10	-0.308	0.202	0.112	-0.608*	0.315	0.008	0.204	0.059	0.494	1.000												
11	-0.406	0.069	0.679**	-0.056	0.079	0.688**	0.527*	0.551*	0.117	0.451	1.000											
12	0.627*	-0.655**	-0.160	-0.013	0.031	-0.067	-0.567*	-0.495	-0.027	0.002	0.168	1.000										
13	0.880**	-0.730**	-0.444	0.035	-0.097	-0.343	-0.826**	-0.754**	0.016	-0.063	-0.045	0.743**	1.000									
14	0.707**	-0.629**	-0.490	-0.146	0.175	-0.404	-0.614*	-0.605*	0.106	0.148	0.034	0.662**	0.760**	1.000								
15	0.511	-0.282	-0.442	0.161	0.409	-0.426	-0.574*	-0.451	0.199	-0.197	-0.281	0.426	0.367	0.531*	1.000							
16	-0.878**	0.919**	0.346	-0.214	0.313	0.192	0.720**	0.666**	0.376	0.332	0.111	-0.792**	-0.856**	-0.674**	-0.419	1.000						
17	-0.438	0.485	0.307	-0.266	0.198	0.241	0.367	0.446	0.105	0.092	0.428	-0.141	-0.087	-0.157	-0.266	0.297	1.000					
18	-0.534*	0.715**	0.100	-0.335	0.587*	-0.055	0.337	0.384	0.444	0.155	0.157	-0.229	-0.403	-0.448	-0.062	0.577*	0.603*	1.000				
19	-0.740**	0.537*	0.580*	-0.004	-0.085	0.476	0.697**	0.680**	-0.120	0.179	0.233	-0.526*	-0.733**	-0.719**	-0.185	0.616*	0.139	0.426	1.000			
20	0.304	-0.350	-0.107	0.031	-0.143	-0.031	-0.306	-0.376	-0.097	-0.084	-0.246	0.333	0.212	0.333	0.097	-0.329	-0.382	-0.591*	-0.491	1.000		
21	0.349	-0.236	-0.122	0.301	-0.362	-0.086	-0.339	-0.325	-0.238	-0.210	-0.457	-0.081	0.188	0.240	0.351	-0.232	-0.360	-0.647**	-0.136	0.540*	1.000	
22	0.752**	-0.445	-0.551*	0.218	-0.251	-0.462	-0.725**	-0.707**	-0.192	-0.494	-0.609*	0.124	0.570*	0.298	0.437	-0.559*	-0.346	-0.439	-0.362	0.169	0.623*	1.000

* Significant at 5 per cent level of significance; ** Significant at 1per cent level of significance.

Malwa plateu, respectively.

An abrupt fall in potassium content in those pedons could be attributable to the washing of finer materials from the surfaces which are exposed regularly to the flood in rainy season. In case of Malwa plateau, its content increase down the slope from hill top to lower elevated plain.

A meticulous examination of data presented in Table 2a and b) reveals a positive and significant (r = 0.627*) correlation with silt and non significant but positive correlation (r = 0.474) with clay, pH (r = 0.269), O.C. (r = 0.101), CEC (r = 0.444) and available potassium in the soils of Aravali mountain ranges. While in the case of Malwa plateau soils it was significant and positive correlation between available potassium content and clay content (r = 0.679**) and CEC (r = 0.688) while Positive and non- significant correlation with silt (r = 0.069) and organic carbon (r = 0.079), pH has negative and non-significant correlation (r = -0.056).

The surface soils of all most all pedons except hill and valley were generally rich in potassium content which may be because of management practices followed in cultivated soils (Gaikwad et al., 1974).

Similar results have also been observed by Rathore (1993) and Sharma (1994).

Micronutrient status

DTPA extractable micronutrients *viz*., Fe, Mn, Zn and Cu are discussed here. The results of the present investigation with respect to available cationic

Table 2b. Correlation matrix for the physico-chemical properties of Aravali transect soils.

S/N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
	FS+VFS	Silt	Clay	pH	OC	CEC	0.03 Mpa	1.5 Mpa	Avail N	Avail P	Avail K	Avail Fe	Avail Mn	Avail Zn	Avail Cu	$CaCO_3$	SiO_2	Al_2O_3	Fe_2O_3	MnO_2	Value	chroma
1	1.000**																					
2	-0.917**	1.000**																				
3	-0.904**	0.885**	1.000**																			
4	-0.299	0.233	0.429	1.000**																		
5	0.306	-0.359	-0.574*	-0.489	1.000**																	
6	-0.886**	0.872**	0.991**	0.460	-0.638*	1.000**																
7	-0.598*	0.689**	0.838**	0.365	-0.523	0.826**	1.000**															
8	-0.788**	0.771**	0.964**	0.482	-0.702**	0.973**	0.882**	1.000**														
9	0.365	-0.539*	-0.740**	-0.482	0.871**	-0.785**	-0.812**	-0.754**	1.000**													
10	0.561*	-0.571*	-0.608*	-0.308	0.678**	-0.627*	-0.293	-0.595*	0.446	1.000												
11	-0.695**	0.627*	0.474	0.269	0.101	0.444	0.144	0.312	0.090	-0.491	1.000											
12	-0.510	0.633*	0.646**	-0.147	-0.189	0.594*	0.801**	0.612	-0.457	-0.169	0.113	1.000										
13	0.907**	-0.761**	-0.758**	-0.267	0.286	-0.764**	-0.379	-0.660**	0.293	0.618*	-0.702**	-0.352	1.000									
14	-0.057	0.251	0.188	0.191	0.215	0.147	0.401	0.143	-0.145	0.196	0.250	0.350	0.160	1.000								
15	-0.097	-0.081	-0.222	-0.144	0.586*	-0.267	-0.358	-0.381	0.559*	0.449	0.230	-0.222	-0.052	-0.193	1.000							
16	-0.677**	0.640*	0.773**	0.374	-0.420	0.790**	0.689**	0.774**	-0.557*	-0.400	0.433	0.519	-0.655**	0.251	-0.204	1.000						
17	-0.071	0.220	-0.003	-0.455	0.148	-0.071	-0.102	-0.107	0.268	-0.365	0.256	0.297	-0.066	0.068	-0.139	-0.042	1.000					
18	-0.345	0.240	0.303	0.034	-0.129	0.293	0.141	0.359	-0.146	-0.283	0.243	0.0084	-0.321	-0.078	-0.216	0.095	0.076	1.000				
19	-0.593*	0.579*	0.704**	0.439	-0.697**	0.721**	0.606*	0.719**	-0.690**	-0.578*	0.201	0.500	-0.612*	-0.161	-0.220	0.413	-0.115	0.033	1.000			
20	0.262	-0.310	-0.432	-0.562*	0.771**	-0.506	-0.439	-0.556*	0.701**	0.439	0.040	0.043	0.185	0.202	0.324	-0.422	0.279	-0.155	-0.344	1.000		
21	0.535*	-0.499	-0.599*	-0.112	0.526	-0.627*	-0.529*	-0.624*	0.535*	0.354	-0.222	-0.517	0.572*	0.097	0.078	-0.623*	0.125	-0.111	-0.723**	0.243	1.000	
22	0.667**	-0.639*	-0.757**	-0.458	0.813**	-0.804**	-0.538*	-0.785**	0.738**	0.702**	-0.346	-0.286	0.660**	0.157	0.234	-0.607*	0.141	-0.257	-0.803**	0.586*	0.822**	1.000

*Significant at 5% level of significance; ** Significant at 1% level of significance.

micronutrients are presented in Table 1.

DTPA - extractable iron (Fe)

The data pertaining to DTPA-extractable iron ranged between 4.61 and 10.04 mg kg^{-1} with a mean value 6.40 mg kg^{-1} in soils of Aravali mountain ranges. All the soils of different landforms in Aravali mountain ranges were found sufficient in available iron considering 4.5 mg kg^{-1} as critical limit. The maximum content of available iron was found in plain (P_4) and lowest in soils of pediments (P_2). While in the soils of Malwa plateau, the content of available iron ranged between 5.86 to 14.20 mg kg^{-1} with a mean value 10.09 mg kg^{-1}. In soils of this transect, the higher content of available iron was observed in pediments followed by hill top (P_6 and P_5) as compared to others landforms. A critical examination of data pertaining to available iron reveals that mostly the available iron content was found to decrease with depth on higher elevation and it was slightly increase on lower elevation/plain. It can be further seen from Table 1 that the content of available iron decrease down the topographic impact. This could be due to the fact that as the topography gets gentler in slope, the clay content increases causing these nutrients to be strongly adsorbed, thereby, creating greater resistance to their extraction. The significant and positive correlation between clay (r = 0.646**), silt (r=0.633*) and CEC (0.594*) while negative and non-significant correlation pH (r = -0.147) and O.C.(r = -0.189) with Fe pointed out in soils of Aravali mountain ranges.

The soils of Malwa plateau registered non-significant and negative correlation between clay (r = -0.160), pH (r = -0.013) with CEC (r = -0.067) with DTPA-extractable iron content It indicates that the topography had negative impact on available iron content which decrease along transect from higher topographical to lower topographical position. Whereas negative and significant correlation with silt (r = -0.655**), positive and non- significant with O.C. (r = 0.031). Similar results were also reported by Singh et al. (1988), Rathore (1993), Sharma (1995) and Sarkar et al. (2002). Lindsay and Norvell (1978) suggested 4.50 mg/kg of DTPA extractable iron as critical limit for available iron. Considering 4.50 mg/kg as critical limits the soils of all pedons in both transects were found to be sufficient in supply of iron. These findings are in agreement with those of Sharma et al. (2003) in soils of semi-arid of Rajasthan.

DTPA-extractable manganese (Mn)

The results obtained with respect to DTPA-extractable manganese are presented in Table 1. The available Mn content ranged between 1.10 and 12.24 mg kg^{-1} with mean value 6.13 mg kg^{-1} in soils of Aravali mountain ranges. All the soils of different landforms in Aravali mountain ranges were found sufficient in available manganese considering 1.0 mg kg^{-1} as critical limit as suggested by Lindsay and Norvell (1978). Higher content of available manganese was observed in soils of hill top (P_1) followed by valley (P_3) and lowest in plain (P_4). While in the soils of Malwa plateau, its content was found to range between 0.55 to 36.84 mg kg^{-1} with a mean value 15.58 mg kg^{-1}. Considering 1.0 mg/kg as critical limits the soils of all pedons in Malwa plateau transects were also found to sufficient in supply of manganese. The maximum content of available manganese was observed in soils of pediment (P_6) followed by hill top (P_5) and lowest in plain (P_8). It was observed that available manganese content decrease down the depth up to some depth and then it found to increase in lower depth horizons while there was no definite pattern with respect to its distribution with slope, in both the transects. The significant and negative correlation of Mn with silt (r = -761**), clay (r = -0.758**) and CEC (r = -0.764**) while negative and non-significant with pH (r = -0.267) and positive non-significant with O.C. (r = 0.286) content in soils of Aravali mountain ranges (Table 2a and b). The non-significant and negative correlation between Mn and clay (r = -0.444), O.C. (r = -0.097), CEC (r = -0.343) while negative and significant correlation with silt (r = -0.730**) and positive non-significant with pH (r = 0.035) in soils of Malwa plateau. The research findings indicate that the topography had impact on available manganese content which decrease along the depth and transect from higher topographical to lower topographical position Kanwar and Randhawa (1967) pointed out that the occurrence of manganese in various forms depends on a number of factors, of which pH is the most important.

The variation in the distribution in available manganese content with depth in different landforms can be ascribed to the position in the transect; further investigation by Sharma and Choudhary (2007) also reported decreasing trend down the depth of available manganese in Solan district of Himachal Pradesh. Kanwar and Randhawa (1967) also noted different trends in content of available manganese while the reviewing the work of available manganese in Indian soils.

DTPA - extractable zinc (Zn)

The data pertaining to available zinc content showed that it ranged between 0.04 to 0.66 mg kg^{-1} with a mean value of 0.23 mg kg^{-1} in soils of Aravali mountain ranges. The maximum content of available zinc was observed in soils of very gently sloping plain (P_4) and lowest in soils of pediment (P_2). In the soils of Malwa plateau, its content was found to range between 0.04 and 2.19 mg kg^{-1} with a mean value 0.92 mg kg^{-1}. The maximum content of available zinc was observed in soils of pediment (P_6) and lowest in plain (P_8). Soils were, in general, found deficient in DTPA-extractable zinc except P_5 and P_6 occurring on hill top and pediment of the Malwa plateau. However, surface layers (30 cm) of pedon P_4 and P_8 found sufficient in available zinc content as these were higher than critical limit (0.60 mg kg^{-1}) as suggested by Takkar and Randhawa (1978) while remaining pedons were found deficient in available zinc content. It is clearly evident from the data that available zinc was found to decrease with depth in Aravali mountain ranges whereas no definite trend was seen in Malwa plateau which could be ascribed to the difference in the distribution of organic carbon down the depth as organic carbon is the major contributor of available zinc. The non-significant but positive correlation was found between Zn and silt (r = 0.251), clay (r = 0.188), pH (r = 0.191), O.C. (r = 0.215) and CEC (r = 0.147) content in soils of Aravali mountain ranges. While in case of malwa plateau non-significant and negative correlation with clay (r = -0.490), pH (r = -0.146) and CEC (r = -0.404) but negative and significant with silt (r = -0.629**) and positive non-significant correlation with O.C. (r = 0.175) was observed. Sharma and Chaudhary (2007) also reported decreasing trend of available zinc from surface to subsurface horizons. To some extent, organic matter reduces the pH of the soil locally which helps in increasing solubility of zinc besides its effect on weathering of minerals containing zinc. Products of organic matter decay may also have chelating effect on zinc and chelated zinc may become available to plant. Further, it is less subjected to fixation reaction. Similar results were also reported by number of workers (Lal and Biswas, 1974; Singh et al., 1988; Rathore, 1993; Sharma, 1995).

DTPA - extractable copper (Cu)

The results obtained with respect DTPA-Extractable copper are presented in Table 1 which were found to ranged between 0.14 and 0.89 mg kg^{-1} with a mean value of 0.52 mg kg^{-1} in soils of Aravali mountain ranges. The highest content of copper was found in soils of hill top (P_1) whereas lowest value in valley (P_3). In the soils of Malwa plateau, its content ranged between 0.48 to 1.15 mg kg^{-1} with a mean value 0.87 mg kg^{-1}. The maximum content of copper was observed in soils of hill top (P_5) followed by pediment soil (P_6) whereas lowest content was found in plain (P_8). It can be seen that except in the soils of P_6 and P_7, the available copper status was found to decrease with the increase in the depth in all the profile of both transects. Considering 0.2 mg kg^{-1} as the critical limit for copper deficiency (Lindsay and Norvell, 1978), all the soils were found in adequate range except B and C horizon of valley (P_3) in Aravali mountain ranges. The non significant and negative correlation of Cu with clay (r = -0.222), silt (r = -0.081), pH (r = -0.144), CEC (r = -0.267) but positive and significant correlation with O.C. (r = 586*) content in soils of Aravali mountain ranges. The non significant and negative correlation with clay (r = -0.442), silt (r = -0.282), CEC (r = -0.426) and positive non-significant correlation with pH (r = 0161) and O.C.(0.409) in Malwa plateau. Kumar et al. (1990) also reported similar trend in soils of Maharashtra state. It can be further seen that there was irregular pattern of distribution of available copper with respect to topography. Jha et al. (1984) and Sharma (1995) also observed similar results.

REFERENCES

Arora CL (2002). Analysis of soil, plant and fertilizers. In fundamental of soil science (G.S. Sekhon, P.K. Chhonkar, D.K. Das, N.N. Goswami, G. Narayanasamy, S.R. Poonia, R.K. Rattan and J. Sehgal, Eds), Indian Society of Soil Science, New Delhi.

Biddappa CC, Venkata Rao BV (1973). Influence of rainfall and elevation on the Physico-chemical properties of some coffee soils of South India. J. Indian Soc. Soil Sci. 21:47-52.

Gaikwad ST, Rao YS, Verma HK G (1974). Characteristics of catenary soils development on basalt parent rock in Nagpur district of Maharashtra state. J. Indian Soc. Soil Sci. 22:181-190.

Hanway J, Heidal H (1952). Soil analysis as used in Iowa State College Testing Laboratory, Ames. Agric. 57:1-31

Jha SN, Mishra LK, Jha NK, Choudhary SN (1984). Distribution of some micronutrients in calcareous soil as influenced by physiography and soil characteristics. J. Indian Soc. Soil Sci. 32:375-377.

Kanwar JS, Randhawa NS (1967). Micro-nutrient research in soil and plants in India. ICAR, New Delhi, India.

Kumar R, Nayyer VK, Sidhu GS, Deshmukh SN (1990). Distribution of available micronutrient cations in some dominant soil series in differentphysiographic units of Bundelkhand region of Madhya Pradesh. J. Indian Soc. Soil Sci. 38:410-415.

Lal F, Biswas TD (1974). Factors affecting the distribution and availability micronutrient elements in major soil groups of Rajasthan: II. Soil profiles. J. Indian Soc. Soil Sci. *22*:333-346.

Lindsay WL, Norvell WA (1978). Development of DTPA soil test for Zn, Fe, Mn and Cu. Soil Sci. Soc. Am. J. 42:421-428.

Minhas RS, Bora NC (1982). Distribution of organic carbon and the forms of nitrogen in a topographic sequence of soils. J. Indian Soc. Soil Sci. 30:135-139.

Olsen SR, Cole CV, Watanable FS, Dean LA (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Deptt. Agric. P. 939.

Pal SK, Singh M (1993). Monitoring the potassium fertility levels of four soil seroes from Northern India over a period of time. J. Indian Soc. Soil Sci. 41:674-677.

Rathore KS (1993). Characterization and classification of soils in a catenary sequence of Jhadole region of Rajasthan. M. Sc. thesis submitted to Rajasthan Agriculture of University, Bikaner.

Sarkar D, Baruah U, Gangopadhyay SK, Sahoo AK, Velayutham M (2002). Characteristics and classification of soils of Loktak catchment area of Manipur for sustainable land use planning. J. Indian Soc. Soil Sci. 50:196-204.

Sharma JC, Chaudhary SK (2007). Vertical distribution of micronutrient cations in relation to soil characteristics in lower Shiwaliks of Solan in North-West Himalaya. J. Indian Soc. Soil Sci. 55:40-44.

Sharma RK (1995). Characterization and classification of soils in a transect of Haldi ghati region of Rajasthan. M.Sc. thesis, submitted to Maharana Pratap University of Agriculture and Technology, Udaipur

Sharma RP, Megh S, Sharma JP (2003). Correlation studies on DTPA-extractable micronutrients vis-à-vis soil properties in some soils of Nagaur district in semi-arid region of Rajasthan. J Indian Soc. Soil Sci. 51:522-527.

Sharma SS (1994). Characterization and classification of soils across a toposequence over basaltic terrain in humid southern Rajasthan M.Sc. (Ag.) Thesis, R.A.U., Bikaner, Campus, Udaipur.

Sharma SS (2000). Characterization and classification of salt-affected soils for land use planning in sub-humid plains of Rajasthan. Ph.D. thesis, Rajasthan Agriculture of University, Bikaner.

Singh K, Ahuja RL, Singh M (1988). Profile distribution of available micronutrients in relation to landforms and soil properties. J. Indian Soc. Soil Sci. 36:828-832.

Subbiah BV, Asija GL (1956). A rapid procedure for the estimation of available nitrogen in soils. Curr. Sci. 25:259.

Takkar PN, Randhawa NS (1978). Micronutrient in Indian Agriculture. Fertility News 2:26.

Yeresheemi AK, Chanal HT, Patagandi MS Satyanarayana T (1997). Salt affected soil of upper Krishna Command, Karnataka. Agropedology 7:32.