 Agropedology 2011, 21 (1), 44-48

Distribution of DTPA extractable micronutrients in arid soils of Churu district, Rajasthan

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Micronutrients have an important role in increasing the productivity and quality of crops. Their availability in soil is dependent on parent material, landform, climatic condition, natural vegetation and land use pattern (Deka *et al.* 1996). The study on vertical distribution of micronutrient cations in soils is helpful in understanding the inherent capacity of soils to supply these nutrients to crops and their downward movement in soils as roots of many crop plants go beyond the surface layer and draw nutrients from sub-surface layers of the soils. Their distribution has been studied by several workers in Punjab, Haryana and Maharashtra but not in arid area of Rajasthan. Thus, the present investigation has been undertaken to study the depth-wise distribution of micronutrients in the soils and to work out the relationship of some important soil properties with the DTPA extractable micronutrient cations.

The district Churu, extending between 27^0 24' to 29^0 00' N latitude and 73^0 40' to 75^0 41' E longitude with an area of 13592 km^2, encompasses vast stretches of sandy flats and undulating sandy plains (dune height of 6 to 50 m) on an altitude of 213 to 400 m above mean sea level. It is bordering to Mahendragarh and Hisar districts of adjoining Haryana state in the east and is encircled with Hanumangarh district in the north; Nagaur, Sikar, Jhunjhunu in south and south east and Bikaner in the west. Aeolian plains are the major landforms, whereas a trap of alluvial plain was also marked along the Kantali river, draining the district. Average annual rainfall is 353.5 mm, increasing from 261.2 mm at Dungargarh to 372.3 mm at Sujangarh. Based on visual interpretation of IRS LISS-III satellite data and subsequent ground-truth verifications, the typical pedons representing soil series (Molasar, Chirai, Modasar, Devas, Masitawali, Saroopdesar, Naurang-pura and Dune complex) were exposed and horizon-wise soil samples were collected for laboratory characterization.

The physical and chemical characteristics of soils were carried out following standard analytical procedures (Jackson 1973; Black 1965). Particle-size analysis was carried out by International Pipette Method (Piper 1966). The pH (1:2 soil water suspension) was determined by pH meter (Jackson 1973). Electrical conductivity (EC) of soil extract was determined using conductivity bridge (Richards 1954). Organic carbon and calcium carbonate content in soils was estimated following methods outlined by Piper (1966). Available iron, manganese, zinc and copper in the soil were extracted with DTPA reagent (Lindsay and Norvell 1978) and were determined with the help of atomic absorption spectrophotometer. Statistical correlation between micronutrient contents and other physical and chemical properties of the soils were studied.

Soils of the district were alkaline and, in general, pH increased with depth (Table 1). The higher pH in soils of Naurangpura series with salt encrustation may be due to higher concentration of Na and Mg ions. The electrical conductivity in the soils is low. The sand content ranged from 92 to 95 % in Dune complex, 79 to 92 in sandy soils with scattered hummocks (Molasar, Chirai, Modasar, Devas series) and 59 to 86% in other soils (Saroopdesar, Masitawali, Naurang-pura series) of inter-dunal plains and alluvial plains. Clay content was higher in the soils of Naurangpura

Table 1. Physical and chemical characteristics of soils

Soil Series	Depth (cm)	Sand	Silt	Clay	WHC	$CaCO_3$	SOC	pH	EC	CEC
		(%)							dsm^{-1}	cmol(p+) kg^{-1}
Molasar: Typic Torripsamments (Aeolian sandy plain with scattered hummocks)										
	0-15	91.0	4.2	4.8	24.4	0.0	0.10	8.1	0.11	2.9
	15-45	86.0	8.3	5.7	28.8	0.0	0.12	8.2	0.12	3.8
	45-90	84.7	7.5	7.8	30.7	0.0	0.10	8.1	0.10	4.9
	90-130	84.1	7.1	8.8	32.6	0.0	0.14	8.1	0.05	4.8
Chirai: Typic Haplocambids (Alluvium modified with subsequent aeolian activity on sandy plain with scattered hummocks)										
	0-12	88.5	4.5	7.0	24.6	1.50	0.09	8.4	0.14	3.0
	12-42	84.8	5.5	9.7	27.3	5.95	0.12	8.5	0.10	4.8
	42-75	83.8	5.9	10.3	29.0	8.20	0.15	8.5	0.11	5.1
	75-90	84.8	5.8	9.4	30.0	9.45	0.12	8.5	0.08	5.4
	90-130	84.5	6.2	9.3	29.6	11.40	0.15	8.4	0.05	5.6
	130-170	80.2	10.2	9.6	29.6	12.85	0.15	8.4	0.05	5.8
Modasar : Typic Torripsamments (Aeolian sandy plain with scattered hummocks)										
	0-20	91.6	3.4	5.0	21.8	0.55	0.09	8.3	0.09	1.9
	20-60	87.8	5.0	7.2	26.2	1.5	0.10	8.4	0.15	3.5
	60-120	85.7	6.0	8.3	28.0	3.8	0.10	8.4	0.25	4.6
	120-160	86.8	6.2	7.0	26.7	4.4	0.08	8.4	0.25	4.6
Devas: Typic Torripsamments (Aeolian on sandy plain with scattered hummocks)										
	0-15	89.5	4.5	6.0	23.00	2.3	0.12	8.3	0.21	2.4
	15-35	84.3	8.5	7.2	26.80	5.8	0.12	8.5	0.21	2.8
	35-50	81.2	9.8	9.0	28.00	8.7	0.16	8.4	0.10	4.8
	50-75	79.5	8.7	11.8	32.00	11.8	0.08	8.4	0.08	6.2
Masitawali : Fluventic Haplocambids (Alluvium modified with subsequent aeolian activity on sandy plain with scattered hummocks)										
	0-15	86.2	7.6	6.2	23.0	0.0	0.21	8.0	0.15	6.2
	15-45	73.5	13.8	12.7	30.8	0.0	0.17	8.3	0.18	7.9
	45-75	66.2	18.0	15.8	36.0	1.8	0.12	8.2	0.17	9.2
	75-120	64.5	20.5	15.0	36.8	4.0	0.21	8.2	0.21	10.3
	120-150	59.3	21.0	19.7	37.8	8.0	0.24	8.1	0.27	12.2
Saroopdesar : Fluventic Haplocambids (Aeolian on flat inter-dunal plain)										
	0-30	85.2	5.8	9.0	26.0	0.0	0.19	8.3	0.10	5.8
	30-60	72.1	13.0	14.9	29.0	0.0	0.15	8.2	0.13	6.7
	60-90	69.0	15.0	16.0	32.9	0.0	0.15	8.3	0.15	9.2
	90-130	63.2	16.0	20.8	36.3	0.0	0.25	8.2	0.20	9.8
	130-160	60.2	21.8	18.0	38.2	0.0	0.25	8.2	0.15	11.5
Naurangpura: Typic Torrifluvents (Alluvium on alluvial plains)										
	0-20	50	30.3	19.7	49.8	9.0	0.35	8.5	0.65	20.8
	20-40	48.7	35.0	16.3	48.4	7.0	0.25	8.4	0.61	21.5
	40-65	75.7	11.7	12.6	32.0	1.1	0.18	8.6	0.54	8.8
	65-105	62.7	18.3	19.0	38.8	0.40	0.25	8.4	0.46	12.7
	105-150	86.4	5.8	7.8	28.0	0.30	0.12	8.2	0.61	5.3
Dune Complex : Typic Torripsamments (Aeolian material on dunes)										
	0-30	94.6	1.3	4.1	24.4	0.0	0.08	8.3	0.00	1.7
	30-70	94.0	1.9	4.2	24.6	0.0	0.05	8.2	0.04	2.0
	70-100	93.7	2.1	4.2	25.2	0.10	0.08	8.2	0.08	2.2
	100-130	93.4	2.0	4.6	25.9	0.20	0.12	8.4	0.12	2.6
	130-180	92.7	2.2	5.1	26.2	0.20	0.12	8.3	0.10	2.6

Table 2. Distribution of DTPA-extractable micronutrients in soils of Churu district of Rajasthan

Depth (cm)	DTPA-extractable micronutrients Zn	Cu	Fe	Mn
	($mgkg^{-1}$)			
	Molasar: Typic Torripsamments			
0-15	0.92	0.72	7.4	15.5
15-45	0.58	0.84	5.3	14.2
45-90	0.54	0.80	4.1	14.1
90-130	0.48	0.80	3.6	12.7
	Chirai: Typic Haplocambids			
0-12	0.74	0.58	8.1	13.2
12-42	0.30	0.54	7.5	12.7
42-75	0.28	0.36	6.1	9.7
75-90	0.32	0.32	5.0	9.4
90-130	0.28	0.36	4.7	9.2
130-170	0.28	0.28	4.7	9.2
	Modasar : Typic Torripsamments			
0-20	0.72	0.44	6.0	10.7
20-60	0.40	0.34	4.3	9.8
60-120	0.28	0.80	5.5	9.3
120-160	0.18	0.68	5.0	9.0
	Devas: Typic Torripsamments			
0-15	1.20	0.28	8.9	9.5
15-35	0.70	0.24	9.0	8.3
35-50	0.70	0.64	4.2	8.1
50-75	0.56	0.44	4.0	6.7
	Masitawali : Fluventic Haplocambids			
0-15	1.20	0.28	8.9	9.5
15-45	0.70	0.24	9.0	8.3
45-75	0.70	0.64	4.2	8.1
75-120	0.56	0.44	4.0	6.7
120-150	0.56	0.28	3.8	6.5
	Saroopdesar : Fluventic Haplocambids			
0-30	0.96	1.00	6.8	18.5
30-60	0.78	1.10	6.0	17.4
60-90	0.66	0.74	5.2	17.0
90-130	0.54	0.76	5.9	14.3
130-160	0.48	0.80	5.8	14.3
	Naurangpura: Typic Torrifluvents			
0-20	1.40	3.30	14.1	24.1
20-40	0.70	3.40	21.0	28.7
40-65	0.64	2.40	14.0	27.8
65-105	1.70	1.60	12.7	24.8
105-150	4.30	1.30	34.6	31.6
	Dune Complex : Typic Torripsamments			
0-30	0.48	0.52	6.2	8.2
30-70	0.34	0.38	5.2	8.4
70-100	0.34	0.28	3.8	6.1
100-130	0.28	0.22	3.8	6.2
130-180	0.18	0.22	3.2	6.2

than soils of Masitawali and Saroopdesar soil series. Generally, $CaCO_3$ increased with depth. The organic carbon content varied from 0.03 to 0.35 % per cent in the soils.

DTPA-Zn ranged from 0.18 to 4.3 mg kg^{-1}. In general, surface horizons had higher DTPA-Zn and decreased with depth (Table 2). Relatively higher DTPA-Zn in Naurangpur and Masitawali soils may be due to addition of $ZnSO_4$ and more organic matter than the coarse textured soils of Dune complex, Molasar, Modasar, Devas and Chirai series. The coarse textured soils on account of higher pH and low organic matter are prone to Zn deficiency (Takkar and Randhawa 1978). The DTPA-Cu in different soils ranged from 0.22 to 3.4 mg kg^{-1} and decreased with depth. The higher DTPA-Cu in surface horizon might be due to addition of organic carbon through biomass.

The DTPA-Fe ranged from 3.2 to 34.6 mg kg^{-1} in different horizons of soil series and decreased with depth. The irregular distribution of Fe in soils of Naurangpura series might be due to weak pedogenic manifestation and alluvial nature of these soils (Sangwan and Singh 1993). These results are in close agreement with the findings of Sharma *et al.* (1985) and Dhir (1977) in arid soils of Rajasthan. The DTPA-Mn varied from 6.1 to 31.6 mg kg^{-1} and decreased with depth in all the pedons. The higher content of Mn in surface soils could be attributed to addition of organic matter and chelating of organic compounds released during decomposition.

The DTPA extractable Fe, Mn and Zn showed significant positive correlation with organic carbon. The available Zn had highest correlation ($r = 0.822$) with organic carbon in soils of Naurangpura series followed by soils of Chirai series ($r = 0.652$). DTPA-Zn had negative correlation with pH in all the soils. The calcium carbonate had negative correlation with Zn in all the soils. Similar kind of relationship was also reported in arid soils of Rajasthan by Sharma *et. al* (1985) and semi-arid soils of Punjab by Verma *et al.* (2008). The higher degree of correlation between available copper and organic carbon was observed in soils of Chirai series ($r = 0.704$) followed by Masitawali series ($r = 0.613$). Calcium carbonate has negative influence on availability of Cu in soils of Saroopdesar and Devas soil series. A significant and positive correlation between Fe and organic carbon was observed in Naurangpura ($r = 0.734$), Saroopdesar ($r = 0.716$) and Devas ($r = 0.941$) soils. Calcium carbonate had negative correlative with DTPA-Fe in all the soils. The DTPA extractable Mn was negatively correlated with pH in soils of Naurangpura, Molasar, Masitawali and Devas series. A significant negative correlation of calcium carbonate on DTPA-Mn was observed in soils of Molasar ($r = 0.460$), Dune complex ($r = 0.448$), Devas ($r = 0.316$) and Chirai series ($r = 0.058$). Micronutrient cations had positive correlation with clay and significant effect was found for DTPA-Fe, Mn and Zn. Higher the clay content in soils, more of surface area available for ion exchange which finally contributes to the greater DTPA extractable forms of these micronutrients.

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Received : 22-07-2009 *Accepted : 04-04-2011*