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Available Micronutrients in Relation to Soil Properties of Ghatol Tehsil, Banswara District of Rajasthan, India

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ABSTRACT

The present study was undertaken to assess the status of micronutrients in relation to soil properties in one hundred soil samples collected from different locations of 25 villages representing the soils of Ghatol tehsil, Banswara district of Rajasthan. In general, textural class of soils was found to be the category of sandy clay loam, clay loam and clay. The content of sand fraction varied from 17.61 to 65.44 per cent with a mean value of 42.58 per cent, silt fraction varied from 10.00 to 47.90 per cent with a mean value of 26.75 per cent and clay fraction varied from 17.65 to 53.07 per cent with a mean value of 30.54 per cent. The pH of soils varied from 7.07 to 8.02 with mean value of 7.52, EC varied from 0.34 to 0.79 dSm^{-1} with a mean value of 0.54 dSm^{-1}, OC varied from 3.74 to 9.91 g kg^{-1} with a mean value of 6.58 g kg^{-1}, $CaCO_3$ ranged from 8.00 to 68.00 g kg^{-1} with a mean value of 31.67 g kg^{-1} and CEC ranged from 7.00 to 40.00 cmol (p+) kg^{-1}. Available Zn ranged between 0.42 to 1.95 mg kg^{-1} with a mean value of 0.84 mg kg^{-1}, available Fe ranged from 2.26 to 28.4 mg kg^{-1} with a mean value of 10.12 mg kg^{-1}. Available Cu ranged between 0.37 to 4.15 mg kg^{-1} with a mean value of 1.07 mg kg^{-1}. Available Mn ranged between 2.10 to 21.85 mg kg^{-1} with a mean value of 9.36 mg kg^{-1}. Organic carbon, clay, and CEC were positively correlated with available Zn, Fe, Cu and Mn while pH, $CaCO_3$ and sand were negatively correlated.

Introduction

The optimum plant growth and crop yield depends not only on the total amount of nutrients present in the soil at a particular time but also on their availability which in turn is controlled by physical and chemical properties of soil. Now-a-days, the agricultural productivity trends to decline due to increased removal of micronutrients resulting from adoption of high yielding varieties and intensive cropping to meet the ever increasing demand of food grains production along with the shift towards high analysis NPK fertilizers and limited use of organic manures during the last three decades (Mathur *et al.*, 2006); Somasundaram *et al.*, 2009; Sharma *et al.*, 2009). Due to the pressure on soil for increasing productivity of the crops after the green revolution in India in 1960s, the native soils began depleting of their nutrient reserves and the crops started responding to micronutrient fertilizers in spite of balanced fertilization with major nutrients.

Micronutrients namely, zinc (Zn), iron (Fe), copper (Cu), manganese (Mn) and boron (B) are essential nutrients required in very small quantities for normal plant growth. Micronutrients are involved in various enzymes and other physiologically active molecules (Gao *et al.,* 2008), although each micronutrient has specific functions in plants and in microbial growth processes. The deficiency and toxicity range in soil of these micronutrients is narrow; therefore the proper assessment of micronutrient status, before their supplementation through internal sources in soil is very important. Micronutrient availability is influenced by numerous soil parameters like, soil pH, organic content, adsorptive surfaces and other physical, chemical and biological conditions in the rhizosphere zone (Pati and Mukhopadhyay, 2011). Soils having heavy texture, lower pH and higher organic matter can generally provide a greater reserve of these elements, whereas, corse textured soils such as sand have fewer reserve and tend to get depleted rather quickly (Yadav and Meena, 2009). Micronutrient availability under southern part of Rajasthan may be influenced by different physiographic regions having difference in soil properties which may finally affect the optimum crop yield. Hence, there is a need to generate database on the status of micronutrients and their deficiency in soils. Agro-ecological zone wise generation of such information is a better approach than done from a particular site. The productivity of soil mainly depends upon its ability to supply nutrients to the growing plants. The crop productivity can be increased by utilizing the available basic information related to soil analysis, use of agro-ecosystem and management practices of soil.

The improper nutrient management has led to emergence of multinutrient deficiencies in the Indian soils (Sharma, 2009). Keeping this in view, the present investigation was carried out to know the distribution of DTPA-Zn, Fe, Cu and Mn and their relationship with soil properties in Ghatol Tehsil.

Materials and Methods

Description of study area

Ghatol tehsil comprising a part of Agro-climatic Zone (IV-b) of Rajasthan. Geographical location of Ghatol tehsil is 23^0 45' 35.04'' N latitudes and 74^0 24' 47.06'' E longitudes with an area of 130499 hectare.

Climate

The climate of Ghatol tehsil is semi-arid characterized by extremes of temperature and low wind velocity.

During the summers, the temperature of Ghatol tehsil remains quite high, like in any other parts of Banswara district. The temperature however, varies between 31°C to 44°C in summer months. The annual rainfall in Ghatol tehsil of Banswara district is about 852 mm.

Geology

The geology of the study area is quite complex. It consists of (1) Archaean age, representing the granite gneissic complex, (2) Aravali system, consisting of quartzite-schists formation and (3) Deccan trap. The geological rock formation belonging to different era and periods are of marked significance.

Present land use

There are two main crop seasons, *kharif* and *rabi*. *Kharif* season begins in June and ends between September to October, while rabi season viz., starts from October and ends in April. The major crops of Banswara district in *kharif* season are sorghum, maize, soyabeen, castor and cotton. In *rabi* season wheat, mustard, barley, gram and poppy are major crops.

Soil sampling

One hundred representative composite soil samples from a depth of 0-15 cm were collected with the help of a wooden *Khurpi*. Samples were completely air-dried and passed through 2 m sieve and stored in properly labeled plastic bags for analysis.

Soil analysis

Soil pH was measured in 1:2.5 soil water suspension using glass electrode pH meter. Electrical conductivity was measured in 1:2.5 soil water supernatant solution with the help of conductivity bridge (Jackson, 1973). The organic carbon was determined by rapid titration method (Walkley and Black, 1934) and $CaCO_3$ by rapid titration method (Puri, 1930). The available Zn and Fe in soil samples were extracted with DTPA (0.005 M DTPA + 0.01 M $CaCl_2$ + 0.1 M TEA, pH 7.3) as per the method described by Lindsay and Norvell (1978) and the concentration of Zn, Fe, Cu and Mn in the DTPA-extract was determined using atomic absorption spectrophotometer.

Results and Discussion

Physico-chemical properties

The data presented in table 1 on soil properties showed that the sand content ranged between 17.61 to 65.44 per cent with a mean value of 42.58 per cent, silt content varied from 10.00 to 47.90 per cent with a mean value of 26.75 per cent and clay content varied from 17.65 to 53.07 per cent with a mean value of 30.54 per cent. The soils are neutral to moderately alkaline (7.07 to 8.02). The alkaline nature of soil under study is attributed to the fairly optimum base saturation in the region (Sharma *et al.*, 1992). The electrical conductivity (EC) ranged from 0.34 to 0.79 dSm^{-1} with a mean value of 0.54 dSm^{-1}. All of the soil samples are under < 1 dSm^{-1}. It indicates that they are less saline in nature as suggested by Muhr *et al.,* (1963) comparatively low content of soluble salts appear to be due to the type of climate (sub-humid) of the area which is fairly sufficient to leach out major part of soluble salts from the soil. The organic carbon ranged from 3.74 to 9.91 g kg^{-1} soil with a mean value of 6.58 g kg^{-1} soil. It showed a considerable variation with types and topography of soil. Relatively higher values of organic carbon can be ascribed to annual addition of plant residues and also the application of FYM. The $CaCO_3$ raged from 8.00 to 68.00 g kg^{-1} with a mean value of 31.67 g kg^{-1} is a useful parameter to assess the extent of nutrient availability and their release behavior. The CEC values ranged from 7.00 to 40.00 cmol (p^+) kg^{-1} with a mean value of 20.77 cmol (p^+) kg^{-1}.

Available zinc

DTPA-zinc ranged between 0.42 to 1.95 mg kg^{-1} with a mean value of 0.84 mg kg^{-1}. Clay and silt are the most active fractions of soil. Most of the zinc bearing minerals such as biotite, hornblende, augite and others are easily weathered and thus released zinc is subjected to secondary soil forming processes such as adsorption of Zn^{2+} ions by clay.

Zinc (Zn^{2+}) ions adsorbed on soil complexes may easily be removed by leaching especially in sandy loam soils and adsorbed zinc is in equilibrium with the soil solution zinc. The amount of extracted zinc is likely to increase with the increase in fineness of the soil texture. It has also been reported that organic matter plays an important role in controlling availability of zinc particularly in alkaline soils (Das, 2000). A close examination of the data in table 2 indicates significant increase in zinc content with increase in organic carbon (r = 0.684**).

Table.1 Ranges and mean values of physico-chemical properties of soils of Ghatol tehsil

Ranges	Soil properties											
	Sand (%)	Silt (%)	Clay (%)	pH	EC (dSm^{-1})	OC g k^{-1}	$CaCO_3$ g k^{-1}	CEC cmol (p+) kg^{-1}	Micronutrients			
									Zn	Fe	Cu	Mn
									mg k^{-1}			
Maximum	65.44	47.90	53.07	8.02	0.79	9.91	68.00	40.00	1.95	28.4	4.15	21.85
Minimum	17.61	10.00	17.65	7.07	0.34	3.74	8.00	7.00	0.42	2.26	0.37	2.10
Mean	42.58	26.75	30.54	7.52	0.54	6.58	31.67	20.77	0.84	10.12	1.07	9.36

Table.2 Correlations between soil properties and available micronutrients of soils of Ghatol tehsil

Micronutrients	Soil properties							
	Sand (%)	Silt (%)	Clay (%)	pH	EC (dSm^{-1})	OC g k^{-1}	$CaCO_3$ g k^{-1}	CEC cmol (p+) kg^{-1}
Zn	-0.044	0.045	0.032	-0.265	-0.036	0.684	-0.628	0.051
Fe	-0.019	-0.014	0.057	0.011	0.011	0.607	-0.449	0.017
Cu	-0.018	0.083	-0.063	-0.056	0.047	0.703	-0.421	0.056
Mn	-0.004	0.009	-0.015	-0.266	0.008	0.928	-0.536	0.006

Level of significance at.05% (**) and.01 % (*)

The availability of zinc increased significantly with increase in organic carbon because zinc forms soluble complexes (Chelates) with soil organic matter component. On the other hand, the availability of zinc reduced significantly with an increase in $CaCO_3$ (r = - 0.628**) and pH (r = - 0.265**) of soil. At high pH and CaCO3 content, zinc forms insoluble compounds such as $Zn(OH)_2$ and $ZnCO_3$ which can reduce the availability of zinc. There was inverse relationship between zinc and pH as the pH increases the availability of zinc decreased. The findings of the present investigation are confirmed by the results of Singh (2006) and Mehra (2007).

Available iron

The data resented in table 1 showed that DTPA-iron ranged from 2.26 to 28.4 mg kg^{-1} with a mean value of 10.12 mg kg^{-1}. The available iron significantly increased with increase in organic carbon (r = 0.607**). On the other hand the availability of iron was reduced significantly with an increase in $CaCO_3$ (r = -0.449**). It was significantly increased with increase in finer fractions (silt and clay) because these fractions are helpful improving the soil structure and aeration of soils. The available iron was found to increase with increase in CEC of soils due to more availability of exchange sites on soil colloids. The availability of iron enhanced significantly with increase in organic matter because (i) organic matter is helpful in improving soil structure and aeration conditions, (ii) organic matter protect the oxidation and precipitation of iron into unavailable forms and (iii) supply of chelating agents, which increase the solubility of iron compounds. On the other hands, its availability was found to be reduced with increase in pH_2 and $CaCO_3$ contents of soils. Most readily available form of iron is Fe^{2+} ions, which convert into less soluble form (Fe^{3+} ions) after oxidation. High pH is responsible for its oxidation. Hence, the availability of iron reduced at higher pH level. Beside this, at high pH iron is also precipitated as insoluble $Fe(OH)_3$ which reduces its availability. The $CaCO_3$ present in soils gets converted into bicarbonates ions which reduces the availability of iron and the chlorosis caused in these conditions is known as a "lime induced chlorosis". The availability of iron at high pH is reduced due to the reduction in its solubility. The solubility of iron decreased with increase in pH is due to the formation of insoluble iron hydroxide and carbonates. Similar results were reported by Gupta (2003) and Yadav and Meena (2009).

Available copper

The data presented in table 1 showed that DTPA-copper varied from 0.37 to 4.15 mg kg^{-1} with a mean value of 1.07 mg kg^{-1}. As given in table 2 the available copper significantly increased with increase in organic carbon (r = 0.703**). On the other hand the availability of copper was reduced significantly with an increase in $CaCO_3$ (r = -0.421*) and pH (r = -0.056). The organic acid molecules present in organic matter solubilise Cu^{2+} ions by chelation and complexion and as a result of this organic binding, there is more dissolved copper in the soil solution than normally occurs in the absence of organic matter. Furthermore the availability of copper enhanced with increase in silt and clay contents and this might be due to the improvement of soil structure and aeration conditions of soils with increase in finer fractions in soil mass. The availability of copper suppresses significantly with sand contents because the coarseness of soil texture reduces the adsorption of Cu^{2+} ions on exchange sites. 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).

Available manganese

The data presented in table 1 showed that DTPA-manganese varied from 2.10 to 21.85 mg kg^{-1} with a mean value of 9.36 mg kg^{-1}. A close examination of data in table 2 indicates that the availability of manganese in these soils enhanced with increase in clay (r = 0.015), organic carbon (r = 0.928**), and CEC (r = 0.006). There was a positive correlation between manganese and organic carbon as the organic carbon content increases the availability of manganese increases. The increase in availability of manganese with increase in clay and silt might be due to the improvement in soil structure and aeration conditions. On the other hand the availability of manganese was reduced significantly with an increase in $CaCO_3$ (r = -0.536**) and pH (r = -0.266**). It might be due to the formation of less soluble compounds like $MnCO_3$ or $Mn(OH)_2$. The higher pH favors the formation of less soluble organic complexes of Mn, which reduces the availability of Mn and the activity of soil micro-organism which oxidizes soluble Mn^{2+} (Singh *et al.*, 2013).

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