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Available Zinc Status in Relation to Soil Properties in some Red and Lateritic Soils of Birbhum District, West Bengal, India

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A B S T R A C T

The present study was undertaken to assess the status of available Zinc in relation to soil physico-chemical properties in nineteen soil samples collected from three different blocks of Birbhum district of West Bengal. In general, textural class ranged from sandy loam to sandy clay loam. Soils were strong to moderately acidic in reaction. Soil organic carbon status ranged from 0.24 to 0.81% and was low in available P status. The DTPA-extractable zinc content in the surface soils under study, varied from 0.37 to 1.28 mg kg^{-1} with an average value 0.856 mg kg^{-1}. Among the samples analyzed, 18% deficient, 67% sufficient and 13% samples were found to be high level in available Zn content in soil. Correlation between the soil physico-chemical properties and available zinc showed a significant and positive relationship with clay content (r =0.535**) and organic matter (r = 0.362**), whereas negative and significant correlation was noticed with soil pH (r = -0.233*) and available P (r= -0.588**).

Introduction

Zinc deficiency is prevalent worldwide in temperate and tropical climates (Slaton *et al.*, 2005, Prasad 2006, Fageria *et al.*, 2011). Indian soils are prone to micronutrient deficit due to intensive cultivation of high yielding varieties and improper nutrient management including high rate application of macronutrients and use of low levels of organic matter (Mathur *et al.*, 2006; Somasundaram *et al.*, 2009; Sharma *et al.*, 2009). Zinc is essential for particular physiological functions in living systems; it plays an important role in different plant metabolism processes like development of cell wall, respiration, photosynthesis, chlorophyll formation, enzyme activity and other bio-chemical functions (Das, 2003). It helps the maintenance of structural and functional integrity of biological membranes (Alloy, 2008 and Hafeez *et al.*, 2013).

Availability of zinc influenced by numerous soil parameters like, soil pH, organic matter content, adsorptive surfaces, and other physical, chemical, and biological conditions in the rhizosphere zone (Pati and Mukhopadhyay, 2011).

High phosphate content of soils or high fertilization with phosphate may reduce the

uptake of zinc and other nutrients (Dadhich and Somani, 2007; Kizilgoz and Sakin, 2010).

Analysis of soil and plant samples has indicated that about 49% of soils in India are potentially deficient in Zn (Singh M.V., 2008 and Gupta, 2005). In West Bengal, 55% of the soils are found to be deficient in Zn (Takkar *et al.*, 1989). Therefore, the objective was framed to study the available zinc status in relation to soil physico-chemical properties of Birbhum district of West Bengal.

Materials and Methods

Study area

Situated between 23° 32' 30" (right above the tropic of cancer) and 24° 35' 0" north latitude and 87° 5' 25" and 88° 1' 40" east longitudes, and about 4,545 square kilometres in area. Geographically, this area lies at the north eastern end of the Chota Nagpur Plateau, as it slopes down and merges with the alluvial plains of the Ganges. The climate on the western side is dry and extreme but is relatively milder on the eastern side. During summer, the temperature can shoot well above 40 °C (104 °F) and in winters it can drop to around 10 °C (50 °F). Rainfall is higher in the western areas as compared to the eastern areas.

Soil sampling and analysis

Thirty soil samples (0-15cm) were collected from each three blocks namely Md. Bazar, Nalhati and Bolpur of Birbhum district, were air dried, ground in a wooden mortar, passed through 2 mm sieve and stored in polythene bags for various analysis.

Soil analysis

Particle size analysis was carried out by Hydrometer method using sodium hexa meta phosphate as a dispersing agent as described by Bouyoucos (1927). Soil reaction (pH) was measured in 1:2.5 soil: water suspension with a digital glass electrode pH meter (Jackson 1973). Electrical conductivity was measured using conductivity meter as outlined by Jackson (1973) under suitable measuring conditions. Walkley and Black's (1934) wet oxidation method was used for determination of organic carbon (OC). Available phosphorus was extracted with Bray No-1 solution as extractant (Bray, 1945) and using spectrophotometer at wave length of 660 nm. Plant available (DTPA–extractable) zinc in soils was extracted using DTPA (0.005 M DTPA + 0.01 M $CaCl_2$ + 0.1 M TEA, pH 7.3) at 1:2 soil to extractant ratio as described by Lindsay and Norwell (1978). Based on the available soil Zn status, the soils were grouped into three categories as, deficient (≤ 0.6), sufficient (0.6-1.2), and high ≥ 1.2 mg kg^{-1} of soil available Zn.

Statistical analysis

The results obtained in respect of soil properties were subjected for simple correlation analysis and the observed 'r' values were tested for 1% and 5% level of significance (Sundarraj *et al.*, 1972).

Results and Discussion

The various physico chemical properties in soils of three different blocks of Birbhum district used in the study are given in Table 1. The mechanical composition of soil indicated that the texture varied from sandy loam to sandy clay loam texture.

Sand was the dominant fraction in these soils, which might be due to high rainfall and the parent material from which the soil was derived. The results of the study were in conformity with the findings of Sathyanarayana and Biswas (1970).

Physicochemical properties

The pH of the surface soils under present investigation showed that most of the soils are strong to moderately acidic in nature. Acidic pH of the soils might be attributed to the type of parent material from which these soils have been derived and leaching of basic cations. This is in agreement with the findings of Chakravarti *et al.,* (1957), who stated that soils of Birbhum districts are acidic in nature. Electrical conductivity in the soils under study and was found to be normal with respect to plant growth, which may be due to low in salt concentration as observed by Chakravarti *et al.,* (1957) and Ray *et al.,* (2012).

Soil organic carbon status in soils of three different blocks ranged from 0.24 to 0.73 %, 0.28 to 0.76 % and 0.25 to 0.81% respectively. Soils from Nalhati blocks showed high amount of organic carbon content. Organic carbon content in most of the soil showed low to medium in range. This might be due to continuous cultivation and scarce application of FYM.

The overall available P of the study area was noted from 12.04 to 42.4 kg ha^{-1} with a mean value of 27.09 kg ha^{-1}, majority of the soils under study showed low available P status. The low available P status in these soils might be due to acidic nature of soil. This result agrees with observations of Deshmukh (2012), Pandit *et al.,* (2016) and Das *et al.,* (2010).

DTPA available Zn content

The DTPA-extractable zinc content in the surface soils under study, varied from 0.37 to 1.28 mg kg^{-1} with an average value 0.856 mg kg^{-1}. The overall samples were found to be 18% in deficient, 67% in sufficient and only 13% samples were found to be high level in available Zn content in soil (Fig. 1). Soils of Nalhati block were found to contain higher amount of DTPA-extractable zinc compared to Md. Bazar and Boplur block soils due to the high organic carbon content as noticed in the present study. The similar results were observed by Krishnamurthy and Srinivasamurthy (2001) and Chidanandappa *et al.,* (2008) and Kumar (2017).

Relationship between DTPA-extractable zinc and soil properties

The data on correlation between soil properties and available zinc status in top soil of Birbhum district were presented in table 2. The current study showed that, DTPA-extractable zinc exhibit positive and significant correlation with clay content (r = 0.535**) and organic matter (r = 0.362**), whereas negative and significant correlation with soil pH (r =-0.233*) and available P (r= -0.588**).

The positive correlation between available zinc and clay content indicates that available zinc status increases with increasing fineness of the soil texture, which helpful to improve soil structure and aeration which are favorable conditions for increasing its availability, similar observation was made by Kumar *et al.,* (2011) and Meena *et al.,* (2017).

Similarly the available zinc status in soils under study increases with organic matter content which may due to the organic acids or compounds produced during the decomposition of organic matter react with zinc and form soluble organo-zinc complexes, which prevent the zinc from fixation by soil constituents and which supply soluble chelating agents which increase the solubility of micronutrient contents, which is in line with findings of Begum *et al.,* (2016), Kumar (2017) and Rai *et al.,* (2018).

Table.1 Physico-chemical characteristics in the soils of Birbhum district

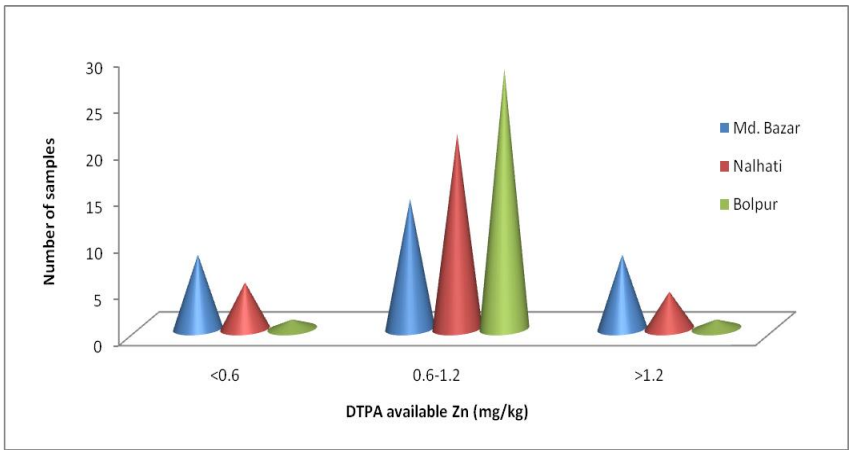
BLOCK		pH	EC (dSm^{-1})	Organic C (%)	Available P (kg/ha)	DTPA-Zn (mg/kg)	Textural Class
Md. Bazar	Range	4.35-5.84	0.01-0.08	0.24-0.73	9.08-43.31	0.33-1.30	SCL
	Mean	4.90	0.04	0.47	26.38	0.84	
Nalhati	Range	5.91-6.94	0.01-0.07	0.28-0.76	18.02-42.89	0.35-1.26	SCL
	Mean	6.47	0.03	0.56	29.72	0.88	
Bolpur	Range	4.66-5.75	0.01-0.07	0.25-0.81	9.21-41.0	0.45-1.28	SCL
	Mean	4.92	0.03	0.49	25.8	0.85	

Table.2 Correlation in between DTPA-extractable zinc and physico- chemical properties in soils of Birbhum district

Properties	DTPA-Zn	pH	OC	Clay	Available P
DTPA-Zn	1.00				
pH	-0.233*	1.00			
OC	0.362**	0.068	1.00		
Clay	0.535**	0.272**	0.146	1.00	
Available P	-0.588**	0.500**	-0.201	-0.465**	1.00

* - Significant at 5 % ** - Significant at 1 %

Fig.1 Status of DTPA available Zn in 3 blocks under Birbhum district



The correlation study suggests that zinc availability decreased with increase in soil pH and available P content probably due to the increased solubility of oxides and hydroxides of Zn at lower pH condition (Talukdar *et al.*, 2009) and formation of insoluble zinc hydroxide and zinc carbonate at higher pH, fixation of zinc by clay in soil and the antagonistic effect of zinc with available P, which is in similarity with findings of Ray *et al.*, (2016).

From the results under this study it can be concluded that available Zn concentrations of

these soils are generally sufficient, whereas 18% of soils under study showed low in available zinc status, the availability of zinc increased with clay content and soil organic matter, whereas it decreased with soil pH and available P in soil. The present investigation may helpful for the improving the nutrient management in red and lateritic soils of Birbhum district.

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