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Distribution of Available (DTPA-extractable) Zinc and Iron and their Relationship with Some Soil Properties in Rice Soils of Chamarajanagar District, Karnataka, India

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A B S T R A C T

A study was under taken to assess the available (DTPA-extractable) zinc and iron in soils under rice based cropping system in Chamarajanagar district, Karnataka, India. Results of the study indicated that the soils were sandy clay loam in texture with neutral to alkaline pH (6.6 to 9.2). The organic carbon content of these soils ranged from 0.12 to 1.05 per cent. Calcium carbonate content varied from 3.62 to 8.75 per cent and DTPA-zinc and iron varied from 0.69 to 2.96 mg kg^{-1} and 6.09 to 32.14 mg kg^{-1}. Correlation studies indicated that available zinc recorded a significant and negative correlation with clay (r=-0.24*) and iron recorded a significant and positive correlation with $CaCO_3$ (r=0.54**) and negatively with pH of the soils (r=-0.50**).

Keywords

Rice, Zinc, Iron, DTPA extractable and Micronutrient.

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Introduction

Rice is the most important staple food crop in the world as well as in India. It serves as a major source of calories for about 60 per cent of the world population. Globally, it occupies an area of 147 m ha with production of 525 m t. Rice is grown in an area of 43.86 m ha with a production of 104.80 m t with an average productivity of 2.65 t ha^{-1} in India and 1.30 m ha with an annual production of 3.66 m t in Karnataka (Anon., 2015). Out of seven micronutrients zinc and iron play a vital role in crop production. Wide spread deficiencies of zinc and iron are noticed. But the incidence of zinc and iron nutrient deficiencies are increasing at an alarming rate in Indian soils on account of the use of large amounts of high chemical analysis fertilizers to hybrids and high yielding crop cultivars (Rajkumar, 1994).

The availability of zinc and iron decreases with increase in soil pH. The pH induced zinc and iron deficiencies in calcareous soils at high pH and precipitation of zinc and iron as insoluble amorphous soil zinc and soil iron and /or $ZnSiO_4$ and $FeSiO_4$, which reduces available zinc and iron in soil. Zinc and iron adsorption on the surface of $CaCO_3$ could also reduce solution zinc and iron. Adsorption of zinc and iron by clay mineral, Fe/Al-oxides, Organic matter and $CaCO_3$ increases with increase in pH (Chidanandappa, 2003).

Zinc and Iron in soils exist in various chemical forms. Contribution of different forms of zinc and iron to available pool vary widely depending upon physical and chemical properties of soils. Several factors mutually interact to govern its solubility in soil solution. These factors influence equilibria of several competing reactions such as solution, complexation, precipitation and occlusion by the matrix of solid and solution phase. So the efficient management of micronutrient that to zinc and iron is vital to sustain the productivity of different crops and to maintain a healthy balance of nutrients in soils. Hence, a study was undertaken to assess the availability of (DTPA- extractable) zinc and iron in soils under rice based cropping system in Chamarajanagar district of Karnataka.

Materials and Methods

Three taluks *viz.*, Chamarajanagar, Yelandur and Kollegal of Chamarajanagar district under paddy land use were selected for the study. Five villages were identified in each taluks and five surface soil samples were collected from each village at 0 to 15 cm (Total 75 soil samples). Collected soil samples were dried under shade, powdered using wooden pestle and mortar and passed through 2 mm sieve. The 2 mm sieved samples were preserved in polythene bags for analysis for different soil properties. The relative distribution of sand, silt and clay in soils was determined by International pipette method (Piper, 1966) and other soil properties such as pH, EC, OC and $CaCO_3$ were analyzed by following the standard procedures as outlined by Jackson (1973). Available zinc and iron (DTPA extractable) was extracted with DTPA extractant (0.005 M Diethylene Triamine Penta Acetic acid + 0.1 M Triethanol amine + 0.01 M $CaCl_2$) at 1:2 soils to extractant ratio, shaken for two hours and filtered as described by Lindsay and Norwell (1978). Zinc and Iron concentration in the filtrate was determined by Atomic Absorption Spectrophotometer under suitable measuring conditions (Page *et al*., 1982).

Results and Discussion

Particle size distribution

The results indicated that among the particle size distribution sand fraction was major fraction in the soils ranged from 50.6 to 68.2 per cent, whereas silt and clay fractions ranged from 9.1 to 18.0 and 20.2 to 33.2 per cent respectively (Table 1). Among the soils of three taluks Yelandur and Kollegal taluk soils recorded higher per cent of sand (52.8 to 68.2 per cent) compared to the soils of chamarajanagar (50.6 to 65.3 per cent) indicating that soils of Yelandur and Kollegal had relatively more coarse texture than that of other soils may be due to the granite type of parent material from which these soils have been derived (Anon., 1986). The results of the study was in conformity with the findings of Sathyanarayana and Biswas (1970) who reported that soils developed from granite type of parent material had a coarse texture.

Chemical properties

The results of the chemical properties viz., pH, EC, OC, $CaCO_3$ and DTPA-Zn and Fe presented in table (Table 1). pH of the soils of selected taluks showed neutral to alkaline soil reaction (6.6 to 9.2) which may be attributed to the basalt and calcitic type of parent material from which these soils are have been derived and also rainfall is relatively low, accumulation of salts as consequence of high water table and poor drainage in command areas (Katti and Rao, 1979). Electrical conductivity ranged from 0.07 to 1.20 dSm^{-1} at 25^0 C there is an increasing trend of salt concentration in these soils may be due to poor drainage of soils. The results are in conformity with the results of Dubey *et al*., (1983) and Katti and Rao (1979) who reported that, the higher electrical conductivity of soils is due to accumulation of salts in the soils. Organic carbon content of the soils ranged from 0.12 to 1.05 percent. Medium to higher organic carbon status of the soils could be attributed to the regular addition of organics in the form of FYM, compost and green manures. Similar observations were noticed by Chidanandappa (2003) and Krishnamurthy (2001) indicating that application of organic manures enhances the organic carbon content in the soils. Medium to high values of $CaCO_3$ (3.62 to 8.75 percent)may be due to the presence of calcium bearing parent materials (Calcite) underneath the surface layer under alkaline soil pH (9.2) was noticed in this study. The results are in conformity with the findings of Ananda (1993).

Available zinc content of the soils under paddy land use in Chamarajanagar district was ranged from 0.69 to 2.96 mg kg^{-1}. The higher content of DTPA-extractable zinc was observed in Kollegal Taluk may be due to higher organic carbon content of the soils. Kuldeep Singh *et al.*, (1988) and Sharma and Lal (1992) reported that the higher amount at the surface layer was related to higher organic carbon content of the soils due to regular addition of plant residues. The similar results were observed by Tiwari and Mishra (1990), Krishnamurthy and Srinivasamurthy (2005) and Chidanandappa *et al*., (2008).

The available iron content of the soils under paddy land use in Chamarajanagar district varied from 6.09 to 32.14 mg kg^{-1}. The higher content of DTPA-extractable iron was observed in Kollegal Taluk. Prasad and Sakal (1991) were in the opinion that the higher amount of available iron might be due to the presence of organic matter indicating that organic matter influenced the solubility and availability of iron which might be due to the chelation of iron which protects itself from oxidation and precipitation of available iron into unavailable form with a consequence of increasing its availability in the soil. Therefore the distribution pattern of DTPA-iron followed the pattern of distribution of organic carbon which might be attributed to their regular addition through crop residues on the surface (Tiwari and Mishra, 1990).

Relationship between available (DTPA-extractable) zinc and soil properties

Available (DTPA-extractable) zinc of the soils correlated significantly and negatively with clay (r=-0.24*) and positive non-significant relationship between organic carbon and $CaCO_3$ (Table 2). The above correlation suggests that zinc availability decreased with increase in soil pH and $CaCO_3$ content probably due to formation of insoluble zinc hydroxide and zinc carbonate at higher pH and the ability of $CaCO_3$ to adsorb zinc and this form of zinc does not come into the solution easily. Similar findings were reported by Katyal and Sharma (1991), Prasad (1991), Nayak *et al.*, (2000) and Chidanandappa *et al*., (2008). These results are in accordance with the results of Sharma and Lal (1992). Majority of the soil samples showed sufficient in available zinc status. This may be due to medium to high organic carbon status of these soils as evidenced by a positive correlation observed between available zinc and organic carbon status of these soils. This suggested that 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. Similar observations were noticed by Chidanandappa (2003), Katyal and Sharma (1991) and Chitdeshwari and Krishnaswamy (1997).

Relationship between available (DTPA-extractable) iron and soil properties

Available (DTPA-extractable) iron of the soils correlated significantly and positively with $CaCO_3$ (r=0.54**). Significantly and negatively with pH (r=-0.50**) (Table 3). The negative correlation between available iron and pH indicated the precipitation of soluble iron into insoluble products. Similar results were also reported by Hazra and Biswapathi Mandal (1988), Yerriswamy (1988), Sahoo *et al*., (1989), Dhane and Shukla (1995), Vadivelu and Bandyopadhyay (1995). The above correlation suggested that iron availability decreased with increase in soil pH and $CaCO_3$ content probably due to formation of insoluble iron hydroxide and iron carbonate at higher pH and the ability of $CaCO_3$ to adsorb iron and this form of iron does not come into the solution easily.

Table.1 Physical and chemical properties (average range) of soils under paddyland use in Chamarajanagar district

Properties	Chamarajanagar taluk	Yelandur taluk	Kollegal taluk	Average range
Physical properties				
Sand (%)	50.6-65.3	56.6-67.8	52.8-68.2	50.6-68.2
Silt (%)	9.8-18.0	9.1-15.0	10.1-16.6	9.1-18.0
Clay (%)	22.6-33.2	20.8-32.1	20.2-32.6	20.2-33.2
Texture	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam
Chemical properties				
pH	7.8 -8.8	6.6-9.2	6.8-9.1	6.6-9.2
EC (dsm^{-1})	0.15 -0.81	0.10-0.65	0.07-1.20	0.07-1.20
OC (%)	0.30-0.78	0.51-0.85	0.12-1.05	0.12-1.05
$CaCO_3$ (%)	3.62-8.42	4.92-8.00	5.20-8.75	3.62-8.75
DTPA-Zn (mg kg^{-1})	0.79-1.97	0.69-1.40	0.85-2.96	0.69-2.96
DTPA-Fe (mg kg^{-1})	6.09-27.31	10.56-30.86	9.26-32.14	6.09-32.14

Table.2 Correlation coefficient (r) between available (DTPA-extractable) zinc and physical and chemical properties of soils under paddy land use in Chamarajanagar district

Properties	DTPA-Zn	pH	OC	Clay	$CaCO_3$
DTPA-Zn	1.00				
pH	-0.15	1.00			
OC	0.16	-0.51**	1.00		
Clay	-0.24*	0.07	-0.09	1.00	
$CaCO_3$	0.10	-0.58**	0.08	-0.26*	1.00

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

Table.3 Correlation coefficient (r) between available (DTPA-extractable) Iron and physical and chemical properties of soils under paddy land use in Chamarajanagar district

Properties	DTPA-Fe	pH	OC	Clay	$CaCO_3$
DTPA-Fe	1.00				
pH	-0.50**	1.00			
OC	0.20	-0.51**	1.00		
Clay	-0.10	0.07	-0.09	1.00	
$CaCO_3$	0.54**	-0.58**	0.08	-0.26**	1.00

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

Similar findings were reported by Katyal and Sharma (1991), Majority of soil samples that were selected for study were sufficient in available iron status. This may be due to the medium to high organic carbon status of these soils as evidenced by a positive correlation observed between available iron and organic carbon status of these soils. This suggested that the organic acids or compounds produced during the decomposition of organic matter react with iron and form soluble organo-iron complexes, which prevent the iron from fixation by soil constituents. Similar observations were noticed by Katyal and Sharma (1991).

It can be concluded that, the soils of selected land use were neutral to alkaline in pH with medium to high in organic carbon content of the soils. The sufficient distribution of calcium carbonates, zinc and iron were noticed. Correlation studies showed a significant relation with clay, calcium carbonate and pH.

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