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The micronutrient status of soils under different land use systems in agro-climatic zones of southern Karnataka

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Abstract
The mineral elements like Zn, Fe and Cu are as crucial for human health as organic compounds such as carbohydrates, fats, protein and vitamins but unscientific land use and cropping techniques have led high soil erosion and degradation of soil quality which cause soil micronutrient deficiency. Hence to understand the effects of land use systems on soil micronutrients status, ten pedons from natural forest and different land use systems of southern agro-climatic zones of Karnataka were determined. The soils were acidic in reaction, non-saline in nature (free of soluble salts) and low (sub-surface soil) to high (surface soil) in organic carbon status. The clay distribution, cation exchange capacity and base saturation of the soils varied from 24.5 to 66.4 per cent, 7.60 to 19.8 cmol (p+) kg^{-1} and 4 to 32 per cent, respectively. Among the DTPA extractable micronutrients, iron and manganese were in sufficient range in most soils, except in central dry zone due alkaline soil reaction. Available copper and zinc were sufficient. The available micronutrients content was found to decrease with increasing the depth of the soils in most soils of different land use systems.

Keywords: Southern Karnataka, land use systems and micronutrients

Introduction

Successful agriculture requires the sustainable use of soil resource, because soils the mineral elements like Zn, Fe and Cu are as crucial for human health as organic compounds such as carbohydrates, fats, protein and vitamins. The daily dietary intake of young adult ranges from 10-60 mg for Fe, 2-3 mg for Cu and 15 mg for Zn. Intake less than these values can cause slow physiological processes. These micronutrients deficiencies in soil are not only hampering the crop productivity but also are deteriorating can easily lose their quality and quantity within a short period of time and produce quality, for many reasons. Agricultural practice therefore requires basic knowledge of sustainable use of the land. A success in soil management to maintain the soil quality depends on the understanding of how the soil responds to agricultural practices over time. Recent interest in evaluating the quality of our soil resource has therefore been simulated by increasing awareness that soil is critically important component of the earths biosphere, functioning not only in the production of food and fiber, but also in the maintenance of local, regional, and worldwide environmental quality. The soil is the source of mineral nutrients for crop production which is not renewable under continuous cultivation due to crop removal as well as leaching and other losses. The dynamic nature of the soil is highly influenced by human induced as well as natural processes of soil formation. With time, soils undergo changes rapidly in their physical, chemical and biological properties.

Micronutrient deficiencies are hampering crop productivity as well as deteriorating produce quality. Also, the low-micronutrient food and feed-stuff are causing serious health hazards in humans and animal. Addition of inputs such as chemical fertilizers, organic manures, insecticides and pesticides alter the properties of soil. Hence, soil testing to know the status of soil fertility is a necessary step towards sustainable soil management. Soil test status based recommendation of nutrients, manures results in better crop production and productivity apart from maintaining soil health. Thus, soil fertility evaluation is a fundamental aspect to keep the soil nutrient balance, which indicates the quantity of nutrients to be added for higher crop yields, besides reducing the cost of cultivation and environmental pollution.

Materials and Methods

The study was undertaken in ten pedons from five districts representing five agro-climatic zones of southern Karnataka (Table 1).

The research work was carried out at College of Agriculture, UAS, GKVK, Bangalore in collaboration with NBSS & LUP, Hebbal, Bangalore. The soil samples were collected horizon-wise, air-dried, powdered and sieved using 2 mm sieve. Particle-size analysis of the samples was carried out by international pipette method. Electrical conductivity, pH, organic carbon, cation exchange capacity and base saturation were determined by standard methods (Jackson 1973) [1]. Exchangeable calcium and magnesium were determined using Versenate (EDTA) titration method. Available micronutrients such as iron, copper, manganese and zinc were extracted using standard DTPA extract at pH 7.3 and the concentration was measured using atomic absorption spectrophotometer (Lindsay and Norvell, 1978) [2].

Table 1: Major land use systems in Southern Agro-climatic zones of Karnataka

District	Taluk	Village	Pedon number	Land use
Udupi District	Brahmavara	Brahmavara	1	Cashew
Udupi District	Brahmavara	Brahmavara	2	Forest
Chikkamagalur	Koppa	Balehonnur	3	Coffee
Chikkamagalur	Koppa	Balehonnur	4	Forest
Hassan	Channarayanapatna	Madnur	5	Coconut + Field crops
Hassan	Hassan	Salegrama	6	Forest
Tumkur	Tiptur	Alburu	7	Areca nut
Tumkur	Tiptur	Alburu	8	Forest
Chitradurga	Hiriyur	Babbur	9	Coconut + Redgram
Chitradurga	Hiriyur	Javagamatur	10	Forest

Table 2: Ranges and means of physical, chemical and physicochemical properties of soils collected from different land use systems and natural forest of Southern Agro-climatic zones of Karnataka

Properties	Range	Mean
pH (1: 2.5)	4.82-8.17	6.49
EC (dSm^{-1})	0.01-0.17	0.09
Organic carbon (%)	0.06-2.28	1.17
Clay (%)	12.17-61.25	36.71
CEC (NH_40Ac pH 7.0)	1.32-37.15	19.23
Base saturation (%)	63.86-97.46	80.66
DTPA extractable micronutrients		
Fe (mg kg^{-1})	1.58-160.9	81.24
Mn (mg kg^{-1})	2.36-70.96	36.66
Zn (mg kg^{-1})	0.04-1.40	0..72
Cu (mg kg^{-1})	0.12-16.84	8.48

Results and Discussion

Range and mean of physical, chemical and physico-chemical properties of different pedons are given in Table 2. All the ten pedons were moderately acidic to moderately alkaline with pH ranging from 4.8 to 8.1 and few land use in Hiriyur are saline in nature (rich in soluble salts). The acidic pH of the soil might be attributed mainly to the leaching of the bases due to the existing high rainfall conditions and to some extent due to the acidic parent materials and even alkaline pH is due low rainfall and high temperature results in accumulation of salts on surface The organic carbon content of the soils varied from 0.06 to 2.28 per cent and was found to be high in surface soils and low in sub-surface soils, decreasing with increasing depth. This is attributed to the addition of plant residues and farmyard manure to surface horizons. The clay distribution of all the six pedon varied from 12.17 to 61.25 per cent. The CEC in all the pedons estimated varied from 1.32 to 37.15 cmol (p+) kg^{+1} soils which correspond to clay content in the horizons, low organic carbon content and also type of clay mineral present in the soil. Base saturation values varied from 63.86 to 97.46 per cent in all the six profiles. Low base saturation might be attributed to the occurrence of high leaching conditions combined with heavy rainfall in the study areas.

Table 3: Depth wise distribution of available micronutrients in different land use systems in Southern Agro-climatic zones of Karnataka

Depth (cm)	Horizon	Available micronutrients (mg kg^{-1})			
		Fe	Mn	Zn	Cu
Pedon 1 (Brahmavara, Cashew)					
0 – 12	Ap	51.44	70.96	0.44	2.64
12 – 37	Bt1	22.20	56.36	0.16	1.32
37 – 57	Bt2	21.00	42.00	0.64	1.28
57 – 94	Bt3	9.16	13.60	0.20	0.56
94 -131	Bt4	8.88	14.20	0.04	0.44
131 – 162	Bt5C	8.28	8.64	0.08	0.52
162 - 180	Bt6C	9.12	9.08	0.12	0.56
Pedon 2 (Brahmavara, Forest)					
0 -20	A	31.08	52.64	0.12	1.00
20 - 48	Bt1	25.68	61.44	0.20	1.40
48 - 80	Bt2	86.20	57.28	0.16	0.88
80 -110	BC	2.78	3.89	0.69	1.68
110 -160	CB	1.58	2.49	0.58	1.03
Pedon 3 (Balehonnur, Coffee)					
0 -18	Ap	160.92	44.28	1.04	0.80
18 - 35	Bt1	97.44	17.20	0.40	0.68
35 - 58	Bt2	38.44	32.08	0.24	0.72
58 - 89	Bt3	22.48	17.00	0.20	0.80
89 - 123	Bt4	15.76	9.60	0.24	0.80

123 - 151	Bt5C	14.68	5.52	0.16	0.88
Pedon 4 (Balehonnur, Forest)					
0 -15	Ap	46.36	31.64	0.60	16.84
15 -31	Bt1	24.60	10.36	0.24	3.24
31 -58	Bt2	21.12	7.04	0.12	0.76
58 -79	Bt3C	12.92	8.60	0.12	0.32
79 - 115	Bt4C	5.80	5.00	0.08	0.12
115- 151	BC	5.60	3.20	0.08	0.12
Pedon 5 (Madnur, Coconut and field crops)					
0 -20	Ap	44.08	23.48	1.40	2.52
20- 36	Bt1	15.32	11.72	0.52	1.88
36 -90	Bt2	6.44	2.80	0.08	1.12
90 - 109	Bt3	6.56	5.36	0.16	1.40
109 - 129	Bt4	6.32	5.16	0.08	1.12
129 -161	BC	7.08	3.00	0.08	0.92
161 - 180	CB	10.32	2.36	0.04	0.44
Pedon 6 (Salegrama, Forest)					
0 -16	A	39.00	56.00	0.40	2.84
16 -41	Bw1	27.96	48.88	0.52	2.92
41 – 60	Bw2	16.16	34.64	0.32	1.60
60 – 107	Bt1	13.64	27.04	0.56	2.48
107 – 151	Bt2	12.84	19.52	0.36	2.56
151 - 200	BC	16.20	39.48	0.48	1.92
Pedon 7 (Alburu, Areca nut)					
0 -20	Ap	19.28	18.96	0.64	0.64
20 -31	Bt1	5.64	20.44	0.52	0.52
31 - 50	Bt2	5.44	15.24	0.16	0.16
50 - 87	Bt3	4.84	13.44	0.16	0.16
87 - 110	Bt4	4.44	12.56	0.12	0.12
110 - 156	Bt5C	4.08	11.56	0.16	0.16
156 - 185	Bt6C	9.64	8.40	0.12	0.12
Pedon 8 (Alburu, Forest)					
0 -20	A	14.16	36.00	0.08	1.76
20 – 44	Bt1	10.32	24.80	0.04	2.96
44 – 78	Bt2	8.16	16.76	0.08	2.80
78 – 125	Bt3	5.60	18.12	0.08	2.84
125 - 161	Bt4C	3.08	4.72	0.04	0.80
Pedon 9 (Babbur, Coconut and Red gram)					
0 -15	Ap	9.32	9.72	0.24	1.92
15 - 33	Bt1	5.32	13.64	0.12	3.04
33 – 50	Bt2	7.12	9.12	0.08	1.08
50 - 72	Bt3C	6.88	10.76	0.08	1.12
Pedon 10 (Javagamatur, Forest)					
0 -12	A	6.04	20.76	0.44	1.08
12 – 26	Bt1	5.16	19.44	0.08	1.48
26 – 40	Bt2	4.92	12.16	0.12	1.76
40 - 68	BC	3.84	9.36	0.04	1.20

Available micronutrients

The examination of the data on available micronutrients of the soils presented in Table 3 revealed that the DTPA extractable iron, manganese, zinc and copper content varied from deficiency to toxicity level in all the pedons. The DTPA extractable Zn ranged from 0.04 to 1.40 mg kg^{-1} soil in surface. Considering 0.60 mg kg^{-1} as critical level for zinc deficiency (Lindsay and Norvell 1978) [2], these soils could be classified as deficient in Zn except surface soils of pedon 3, 5 and 7. The low concentration of Zn in pedon 9 and 10 due to higher pH values in moderately alkaline range. The relatively high content of available zinc in surface horizons may be attributed to variable intensity of the pedogenic processes and complexing with organic matter which resulted in chelation of Zn.

All the pedons were found to be sufficient in available copper (0.12 to 16.84 mg kg^{-1}) as all the values were well above the critical limit proposed (0.20 mg kg^{-1}) by Lindsay and Norvell (1978) [2]. A decreasing trend with depth was noticed in all the pedons except in 9, 8 and 6 which showed in irregular trend with depth. The available Cu content was more in surface layers and decreased with depth, which might be due to association with organic carbon.

The DTPA extractable Fe content varied from 1.58 to 160.9 mg kg^{-1} soil. According to critical limit of 4.5 mg kg^{-1} (Lindsay and Norvell, 1978) [2], the soils were rich in available iron. The higher concentration of DTPA-Fe in subsurface horizons of pedons 1, 2, 3, 4, 5 and 6 might be due to the accumulation of iron brought down as a result of illuviation of clay from the upper horizons. However, the higher DTPA-Fe in surface horizons of all the pedons might be due to accumulation of organic carbon in the surface horizons. Even the higher concentration of micronutrients found in coastal zone due to high rainfall and high temperature in the granite gneiss landscape and laterization assisted the accumulation of sesquioxides under redoximorphic conditions favoring high concentration of Fe and Mn ions and sometimes Cu also in coastal areas as observed by Badrinath *et al.* (1986) [3]. The organic carbon due to its affinity to influence the suitability and availability of iron by chelating action might have protected the iron from oxidation and precipitation, which consequently increased the availability of iron in the surface horizons (Prasad and Sakal, 1991) [4].

Available Mn varied from 2.36 to 70.96 mg kg^{-1} soil and decreased with depth which might be due to higher biological activity and organic carbon in the surface horizons. The higher content of available Mn in surface soils was attributed to its chelation by organic compounds. These observations are in accordance with the findings of Verma *et al.* (2005) [5]. The micronutrient analysis of different land use systems of Southern Agro-climatic zones of Karnataka indicated that the surface soils and subsurface soils are sufficient in DTPA extractable Fe and Mn. Available copper content in surface and subsurface soils of all the pedons was in sufficient range.

Conclusion

Micronutrients nutrition of crops has immense economic importance since an adequate supply of micronutrients can help to ensure that optimum yields are obtained with the given inputs of other crop requirements. Land use change influences a number of biological and physiological processes. Poor land use decisions can lead to land degradation and poor soil health. The variations in soil fertility parameters suggest the immediate need for improvement in soil health. Moreover, it is suggested that sustainable soil nutrient management practices with increased organic matter addition, practices of crop rotation, biomass incorporation, increasing crop diversity, maintaining soil cover in cultivated systems so that micronutrient status can improve.

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