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Soil fertility status and nutrient index for primary nutrients in Western Ghats and Coastal Karnataka under different agro-ecological systems

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Summary

Study was undertaken in Western Ghats and Coastal area in Karnataka state, India with the aim of evaluating the fertility status of soils using nutrient index approach, mainly for primary nutrients. Based on fertility ratings, pH of soils was strongly acidic to moderately acidic. Electrical conductivity was normal (<1.0 dS m^{-1}). Soil organic carbon was medium to high. Primary nutrient status *i.e.*, N, P and K were low in >60 % samples. Whereas, >80 % of samples were low in exchangeable Ca, Mg and available S content. Among the micronutrients Cu and B were found to be low in >70% of samples, whereas Fe, Mn and Zn were adequate in >85 % of samples. Nutrient index value for major nutrients (available N, available P and available K) was found to be low (<1.67 range).

Key words : Fertility, Primary, Nutrient index, Micronutrients

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Introduction

The Western Ghats and Coastal Karnataka is situated between 12.50' N and 14.49' N latitudes and 75.14' E –74.08' E longitudes, which receives an average annual rainfall of >3500 mm. Brown forest soils occur mainly in the Western Ghats under forests, in humid and sub-humid climate. They cover 6 per cent of the total geographical area of Karnataka and have developed on granites, gneisses and schists. Whereas, West Coast of Karnataka located between the Western Ghats and the Arabian Sea. They occupy approximately 3.9 per cent of the total geographical area of the state and mainly comprises of two types of soils *viz*., coastal laterite soils and coastal alluvial soils.

Soil fertility is a dynamic natural property and it can change under the influence of natural and humaninduced factors. Soil organic matter is an important factor in deciding management system of the forest soil fertility. The forest soils vary in physico-chemical changes with time and space resulting in variation among topography, climate, weathering processes, vegetation cover and microbial activities and also biotic and abiotic factors (Sannappa and Manjunath., 2013). Soil fertility fluctuates throughout the growing season each year due to alteration in the quantity and availability of mineral nutrients by the addition of fertilizers, manure, compost, mulch and lime in addition to leaching. Hence, evaluation of fertility status of the soils of an area or a region is an important aspect in the context of sustainable agriculture.

The physical and chemical attributes of soil regulates soil biological activity and exchange of ions between the solid, liquid and gaseous phases which influence nutrient cycling, plant growth and decomposition of organic materials. Organic carbon content in soils has an index of available nitrogen. Organic matter is one of the important factors to determine quality of soil and serves as sources of nutrients for improving physical and biological properties of soils in addition to productivity. The soil chemical environment is dynamic, and reactions that maintain dilute solution of nutrient elements are indispensable for continual plant growth. The nutrient transformation and its availability in soils depend on pH, clay minerals, cation and anion exchange capacity, with this brief introduction the present studies on nutrient status and nutrient index for primary nutrientsin Western Ghats and coastal Karnataka was carried out.

Resource and Research Methods

70 surface soil samples (0-15 cm depth) were collected from farmer's field in and around the vicinity under different land use *viz*., rubber, coconut, multistoried cropping system, arecanut, paddy, forest areas consisting of silveroak, cashew etc., representing major production system in Sullya, Beltangadi, Kollur, Brahmawar, Molahalli, Ullala and Murdeshwara areas of Western Ghats and Coastal Karnataka, 10 soil samples were collected from each area by taking into consideration of above said major production systems.

The processed soil samples were analyzed for pH (2:5 soil water suspension), electrical conductivity (conductivity meter), organic carbon (Walkley and Black, 1934), available phosphorus by spectrophotometer (Bray and Kurtz, 1945), available potassium (Flame photometer), available calcium and magnesium (Neutral normal ammonium acetate), sulphur ($Cacl_2$ Extraction), micronutrients such as copper, iron, manganese and zinc (DTPA Extractable) and boron (Hot water extraction). Mean values of the each nutrient was calculated following standard procedures as ascribed by Gomez and Gomez (1984).

Nutrient index:

The nutrient index categorization and calculation were done as proposed by Ramamoorthy and Bajaj (1969), which are discussed below:

N.I = {(1 x A) + (2 X B) + (3 X C)}/ TNS

where,

A = Number of samples in low category;

B = Number of samples in medium category;

C = Number of samples in high category,

TNS = Total number of samples.

The nutrient index with respect to available N, available P and available K were used to evaluate the fertility status of soils in Western Ghats and Coastal Karnataka. The rating chart is given in Table A.

Table A : Nutrient index ranges and remarks

Nutrient index ranges	Remarks
Below 1.67	Low
1.67-2.33	Medium
Above 2.33	High

Research Findings and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

pH, electrical conductivity and organic carbon :

Soil pH :

Soil reaction ranged from strongly acid to moderately acidranging from pH 4.8 to 5.8 with mean value of 5.38 (Table 1). The soils of Western Ghats and Coastal Karnataka are generally acid in reaction brought out by the intense rainfall and consequent leaching of bases. The acidity of the study area is also aggravated by heavy input of acidic fertilizers and lack of inputs to neutralize acidity (Kavitha and Sujatha, 2015).

Electrical conductivity :

The electrical conductivity of the soils in study area varied from 0.01 to 0.06 dS m^{-1} with mean value of 0.023 dS m^{-1} (Table 1). The low EC of soils may be due to leaching of soluble salts by irrigation water and high rainfall. The condition in study area prevailed was not favourable for accumulation of salts through externally added fertilizers (Roy and Landey, 1962).

Organic carbon:

The organic carbon ranged from 5 to 24.8 g kg^{-1} soil with mean value of 9.21 g kg^{-1} (Table 1). High amount of residues like root biomass left after harvest as well as rapid rate of decomposition due to high temperature, organic matter degradation taking place at faster rate coupled with high vegetation cover, thereby leaving more chances of accumulation of organic matter in the study area. Moreover, soils of West Coast and Western Ghats being rich in low activity clays as they are laterite soils, it is essential to maintain high levels of organic matter in the soils. High levels of organic matter not only provides part of the N requirement of crop plants, but also enhance nutrient and water retention capacity of soils and create favourable physical, chemical and biological environment (Kavitha and Sujatha, 2015).

Primary nutrients (N, P and K):

Available N:

The nitrogen content of the soils of the various agro ecosystems in study area ranged between125-627.2 kg ha^{-1} with mean value of 273.83 kg ha^{-1}(Table 1). About 67.14 per cent samples were found to be low in available N content, whereas about 31.42 and 1.42 per cent of samples were under medium and high category ranges (Table 2), respectively. Even with high organic carbon status of the soils under study, low nitrogen status of the soil may be due to the low mineralization of organic matter as the soils are acidic. It is a fact that the area receives very high rainfall (3500 mm) which results in loss of N due to leaching and denitrification in the soils. Therefore, the soils could retain only a limited quantity of mineralized N. The results are in confirmation with those of Usha and Jose (1983) in laterite soils of Kerala. Exceptionally high N-content (627.2 kg ha^{-1}) in some sites is due to indiscriminate use of fertilizers.

Available P:

The phosphorus content of soils in study area ranged between 2.5-112.50 kg ha^{-1} with mean value of 15.94 kg ha^{-1} (Table 1). About 67.14 per cent of samples were low in available P content and about 28.57 and 12.85 per cent of samples were medium and high category range, respectively (Table 2). The low status of available P is attributed to its higher removal than replenishment and fixation of P as Fe-P and Al-P as they are generally laterite soil which are rich in hydrated as well as amorphous oxides of Fe and Al (Mini, 2003). Similarly, low status of available P in Western Ghats was recorded by Sathisha and Badrinath (1994). Available P content was medium at some sites in the study area where pH was moderately acidic. The near neutral pH have a significant role in enhancing the P availability. Available P increases with pH and decreases with organic carbon. The increase in available phosphorus due to increase in pH may be due to lowering of activities of Fe and Al^{3+} which increases the solubility of strengite and variscite and increases electro-negativity of colloidal complex with a consequent decrease in sorption of P (Dhanya *et al.*, 2009). Whereas, high in available P might be due to the different management practices followed among the farmers.

Available K:

The available K content in soil ranged between 28–

Table 1 : Descriptive statistics of soil samples analyzed for different chemical properties in study area (n=70)

Parameters	Descriptive statistics		
	Mean	Minimum	Maximum
pH	5.38	4.90	5.80
E.C (dS m^{-1})	0.023	0.01	0.06
O.C (g kg^{-1})	9.215	5.00	24.80
Available N (kg ha^{-1})	273.83	125.00	627.20
Available P (kg ha^{-1})	15.94	2.50	112.50
Available K (kg ha^{-1})	108.10	28.00	356.00
Exchangeable Ca (mg kg^{-1})	205.10	108.00	356.00
Exchangeable Mg (mg kg^{-1})	77.70	13.00	173.00
Available S (mg kg^{-1})	1.99	0.06	11.80
Available Fe (mg kg^{-1})	30.3 0	7.20	90.40
Available Mn (mg kg^{-1})	6.86	2.30	18.80
Available Zn (mg kg^{-1})	3.78	0.60	10.80
Available Cu (mg kg^{-1})	2.92	0.40	15.60
Available B (mg kg^{-1})	0.409	0.05	2.40

356 kg ha^{-1} with mean value of 108.10 kg ha^{-1} (Table 1). However, about 91.42 per cent samples recorded low available K status, whereas 8.57 per cent samples recorded medium range (Table 2). Coarse textured and gravelly soils with deeper solum are particularly low in available potassium, possibly due to faster and deeper leaching and physico-chemical properties (Srinivasan *et al.*, 2013). The results are in line with Sanappa and Manjunath (2013) who recorded low available K status in lateritic soils of coastal plain and Western Ghats of Karnataka.

Secondary nutrients (Ca, Mg and S) :

Exchangeable Ca:

The exchangeable Ca ranged between 108-356 mg kg^{-1} with mean value of 205.1 mg kg^{-1} (Table 1). About 98.50 per cent samples were deficient in Ca content and meagre samples of about 1.50 per cent were adequate in Ca content (Table 2). As these soils are formed from the acid parent material, granite or peninsular gneiss, which are inherently low in calcium content. Moreover, Heavy rainfall in the coastal areas causes leaching losses of Ca and also due to continuous addition of acidifying chemical fertilizers (Kavitha and Sujatha, 2015).

Exchangeable Mg:

The exchangeable Mg in study area ranged between 13-173 mg kg^{-1} with mean value of 77.70 mg kg^{-1} (Table 1). About 92.85 per cent samples were deficient in Mg content and 7.15 per cent samples were in adequate range (Table 2). Similar to calcium, magnesium retention in exchangeable form decreases in acid soils due to decrease in variable charge, and it is mainly present in soluble form. Also, Mg being a poor competitor with Al and Ca for the exchange sites tends to accumulate in solution phase and subjected to leaching losses in acid soils (Edmeades *et al.*, 1985).

Available S :

The available S content in soil range between 0.06-11.8 mg kg^{-1} with mean value of 1.99 mg kg^{-1} (Table 1). About 84.28 per cent samples recoded deficient in available S content, whereas only 15.71 per cent samples recorded adequate (Table 2). Deficiency of sulphur is due to low pH and low content of sulphur bearing minerals (Anathanarayana *et al.*, 1986). Moreover, coarse texture soil, inherent low organic matter content and soil conditions that favour sulphur leaching losses are also reason for low available sulphur in soil (Patra *et al.*, 2012).

Micronutrients (Fe, Mn, Zn, Cu and B):

Available Fe:

Available Fe ranged between 7.2-90.4 mg kg^{-1} with mean value of 30.30 mg kg^{-1} (Table 1) and 100 per cent of samples were in sufficient range *i.e.*,> 4.5 mg kg^{-1} (Table 2). This is due to high organic carbon prevailing in study area might have influenced the suitability and availability of iron by chelating action which might have protected the iron from oxidation and precipitation, which consequently increased the availability of iron (Prasad and Sakal, 1991).

Table 2 : Number or per cent of samples in low, medium and high categories of different chemical properties (n=70)

Parameters	% Samples			
	Range / Critical limit	Low	Medium	High
Available N	280-560 kg ha^{-1}	67.14 (47)	31.42 (22)	1.42 (01)
Available P	11-24 kg ha^{-1}	67.14 (47)	28.57 (20)	12.85 (13)
Aqvailable K	116-275 kg ha^{-1}	91.42 (64)	8.57 (06)	-
		Adequate	Deficient	
Exchangeable Ca	300 mg kg^{-1}	98.5 (69)	1.5 (01)	
Exchangeable Mg	120 mg kg^{-1}	92.85 (65)	7.14 (05)	
Available S	10 mg kg^{-1}	84.28 (59)	15.71 (11)	
Available Fe	2.5-4.5 mg kg^{-1}	100 (70)	-	
Available Mn	2.0 mg kg^{-1}	95.71 (67)	4.29 (03)	
Available Zn	1.0 mg kg^{-1}	14.28 (10)	85.71 (60)	
Available Cu	2.00 mg kg^{-1}	80 (56)	20 (14)	
Available B	0.50 mg kg^{-1}	72.85 (51)	27.14 (19)	

*Figures in parenthesis indicates number of samples

Available Mn:

Available Cu ranged between 2.3-18.8 mg kg^{-1} with mean value of 6.86 mg kg^{-1}(Table 1). About 95.71 per cent of samples were deficit in available Mn content, whereas meagre 4.28 per cent of samples were in sufficient range (Table 2). Similar to Fe, the higher content of available Mn in surface soils is attributed to its chelation by organic compounds released during the decomposition of organic matter and crop residues, as the study area covers most of the plantation crop with tropical ecological region. These observations are in accordance with the findings of Verma *et al.* (2005).

Available Zn:

The available Zn content in soils ranged between 0.6-10.8 mg kg^{-1} with mean value of 3.78 mg kg^{-1} (Table 1). About 14.28 per cent samples recorded deficit in available Zn content, whereas about 85.71 per cent samples were in adequate range (Table 2). This element occurs as a contaminant in phosphatic fertilizers. So continuous addition of chemical fertilizers might have increased the adequate levels of zinc in these soils. The present results are in line with those of Kavitha and Sujatha (2015) who found adequate Zn content in soils of Kerala.

Available Cu:

Available Cu ranged between 0.4-15.6 mg kg^{-1} with mean value of 2.92 mg kg^{-1} (Table 1). About 20 per cent of samples were deficit in available Cu content, whereas about 80 per cent of samples were in sufficient range (Table 2). As most of soils in study area are acidic, with decrease in soil pH the adsorption of Cu to the permanent charges will decrease, which is the common phenomena making it higher available to crop. Moreover, Cu being ingredient in fungicide and their frequent application either to soil or crops might have increased their level in the soils. At higher pH, Cu adsorb to variable charge sites by formation of inner-sphere complexes at crystal edges or alumina sheet surfaces, thereby decreasing their availability to the crop (Srivastava *et al.*, 2005).

Available B:

Available B ranged between 0.05-2.40 mg kg^{-1} with mean value of 0.409 mg kg^{-1} (Table 1). About 72.85 per cent of samples were deficit in available B content, whereas about 27.14 per cent of samples were in sufficient range (Table 2). Deficiency of boron in the study area might be due to complexation with silicate mineral and leaching by high rainfall (Bhandari and Randhava, 1985). In general, management of B in the soil is difficult because of its high mobility and fixations at high pH (Saleem *et al.*, 2010).

Soil nutrient indices for major nutrients in Western Ghats and West Coast of Karnataka:

Soil nutrient index was calculated for low, medium and high ratings of soil nutrients. If the index value is less than 1.67, the fertility status is low and the value between 1.67-2.33 and the status is medium (Table A). If the value greater than 2.33, the fertility status is high. All the major nutrients *viz.*, N, P and K were found to be low in fertility status with nutrient index value of 0.71, 1.37 and 1.09, respectively (Table 3). But, according to Ravikumar and Somashekar (2014), the NPK status of Karnataka was L-L-H. Whereas, in Uttar Pradesh the NPK status was L-M-M (Kumar *et al.*, 2013).

Table 3 : Nutrient index values of major nutrients in Western Ghats and West Coast of Karnataka

Parameters	Nutrient index value	Fertility status
Available N	0.714	Low
Available P	1.371	Low
Available K	1.085	Low

Conclusion:

Based on the soil analysis data,it was observed that almost all the nutrients were in low to medium range in Western Ghats and West Coast of Karnataka. The nutrient index value clearly indicated that the major nutrient were low in soils. Moreover, there was no much variation in the mean value from the actual values. The study mainly emphasizes on soil fertility management in Western Ghats and Coastal Karnataka through different scientific approaches.

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