The Pharma Innovation Journal 2021; 10(11): 527-530

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 527-530

www.thepharmajournal.com
Received: 10-09-2021
Accepted: 28-10-2021

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The impact of different land use and management on macronutrient status in soils of Southern Agro-climatic zones of Karnataka

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Abstract
Nutrient sufficiency is the basis of good health, productive lives and longevity for human hence Understanding soil properties and their productiveness under different land use management have proved to be useful for sustainable development and efficient utilization of limited land resources. The current study seeks to assess sustainability of agricultural land use by identifying the effect of land use change on soil macronutrient status. To understand the effects of land use systems on soil macronutrient 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 (subsurface 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. The macronutrients status of the soil samples indicated that the available nitrogen content varied from low to medium in all the pedons, the soils were low in available phosphorus, low to medium in available potassium and available sulphur.

Keywords: Nutrient sufficiency, land use systems, southern Karnataka and macronutrients

Introduction

The soil quality has important elements such as soil compatibility, erodibility and soil fertility. Among these, the problem of declining soil fertility endangers maximum productivity. Warren and Agnew (1988) [1] described that of all the threats to sustainability, the threat due to soil fertility depletion is the most serious. Depending upon the cropping pattern, leaching, erosion *etc*., Soil loses a considerable amount of nutrients every year. If cropping is continued over a period of time without nutrients being restored to the soil, its fertility will be reduced and crop yields will decline. Poor soil fertility conceives sparse plant cover, which promote erosion vulnerability. This happens because 90 percent of plant available nitrogen (N) and sulphur (S), 50-60 per cent potassium (K), 25-30 per cent phosphorus (P) and almost 70 per cent of micronutrients reside in organic matter (Stevenson, 1982) [3]. Soil fertility is meant for highlighting the nutrient needs, based on fertility status of soils (and adverse soil conditions which need improvement) to realize good crop yields. In southern Karnataka soils are red and lateritic, Bramhavara, Udupi District on which cashew are often grown are very poor in fertility and the yields are low in these soils unless the trees are fertilized regularly. The laterite soils are varying considerably in depth, texture and other physical and chemical properties. Available macro and micronutrient status in soil profile help in determining the potential of the soil to supply nutrients for crop growth. Soil testing provides information regarding nutrient availability in soils which forms the basis for the fertilizer recommendations for maximizing crop yields. The present study is under taken, in order to provide information on soil macronutrient status of different land use systems selected in southern Agro-climatic zones of Karnataka.

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 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) [4].

Available nitrogen was estimated by alkaline permanganate method (Subbaiah and Asija, 1956) [5]. For available phosphorus determination, extraction was done using Brays extractant and then subsequent estimation by Jackson, (1973) [4] method. Available potassium was extracted using neutral normal ammonium acetate and measured with flame photometer (Jackson, 1973) [4]. Sulphur was extracted using 0.15 per cent $CaCl_2$ solution and was made to react with $BaCl_2$ to form turbid solution of $BaSO_4$. The intensity of turbidity was measured using spectrophotometer at a wavelength of 420 nm (Jackson, 1973) [4]. Exchangeable calcium and magnesium were determined using versenate (EDTA) titration method.

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.

Available macronutrients

Data on available macronutrient contents of soils of different pedons are given in Table 3. The available nitrogen content in all the pedons was rated as low to high and the range of available nitrogen varied from 122.4 to 558.8 kg ha^{-1} throughout the depth. However, available N content was found to be maximum in surface horizons and decreased regularly with soil depth, which might possibly be due to the accumulation of plant residues, debris and rhizosphere. The available nitrogen was more than 340 kg ha^{-1} hence rated medium (Srinivasamurthy *et al.*, 1999) [6].

The available phosphorus content in the pedons varied from 2.80 to 32.15 kg ha^{-1} and was rated as low to high. However, the highest available P was observed in the surface horizons and decreased regularly with depth. Higher P in the surface horizon might be due to the confinement of crop cultivation to this layer and supplementing of the depleted phosphorus externally through fertilizers. Low available phosphorus of soils was due to the prevalence of heavy rainfall which leached all the base cations leaving mostly Fe and Al oxides, which fixes available phosphorus.

Available potassium ranged from 43 to 417.69 kg ha^{-1} and in most of the study area soils were with low to high level of potassium. The highest available K content was noticed in the surface horizons and showed decreasing trend with depth. This could be attributed to more intensive weathering, release of labile K from organic residues and application of K fertilizers. 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 (Badrinath *et al.*, 1986) [7]. Rating for available potassium indicate that values less than 168 kg ha^{-1} are low 168 to 337 kg ha^{-1} as medium as and more than 337 kg ha^{-1} as high (Srinivasamurthy *et al.*, 1999) [6].

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
Available (Av.) and exchangeable (Ex.) macronutrients		
Av. nitrogen (kg h^{-1})	122.4-558.8	340.60
Av. phosphorus (kg h^{-1})	2.80-32.15	17.47
Av. potassium (kg ha^{-1})	43-417.69	230.34
Av. sulphur (mg kg^{-1})	3.37-17.79	10.58

Ex. calcium (cmol (p+) kg^{-1})	9.53-511.61	260.57
Ex. magnesium (cmol (p+) kg^{-1})	6.75-224.54	115.64

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

Depth (cm)	Horizon	OC (%)	Available macronutrients					
			N	P	K	Ca	Mg	S
			Kg ha^{-1}			(Cmol (p') kg^{-1})		(mg kg^{-1})
Pedon 1 (Brahmavara, Cashew)								
0 – 12	Ap	2.28	372.46	8.28	294.76	32.26	13.28	15.97
12 – 37	Bt1	0.85	304.74	6.32	187.45	25.56	13.63	13.12
37 – 57	Bt2	0.44	237.02	6.05	96.99	26.07	16.28	9.71
57 – 94	Bt3	0.34	203.16	4.31	60.26	25.71	19.07	11.24
94 -131	Bt4	0.14	186.23	4.94	63.12	19.15	16.66	10.23
131 – 162	Bt5C	0.16	167.7	3.22	54.85	13.68	13.70	11.12
162 - 180	Bt6C	0.06	153.9	3.12	45.16	9.53	11.18	5.15
Pedon 2 (Brahmavara, Forest)								
0 -20	A	1.75	487.81	13.76	70.91	45.65	13.10	13.32
20 - 48	Bt1	1.36	370.88	12.71	44.04	9.96	7.67	13.19
48 - 80	Bt2	0.56	221.67	11.19	71.55	6.83	10.78	5.58
80 -110	BC	0.5	219.52	2.80	43.00	22.33	15.11	3.37
110 -160	CB	0.3	163.07	3.92	43.00	88.66	6.75	5.06
Pedon 3 (Balehonnur, Coffee)								
0 -18	Ap	2.11	457.11	9.02	155.82	96.25	25.41	15.54
18 - 35	Bt1	1.13	437.11	9.10	146.12	76.12	25.08	12.24
35 - 58	Bt2	0.54	423.25	8.67	139.44	70.51	24.09	11.14
58 - 89	Bt3	0.34	304.74	8.43	115.27	85.91	29.48	10.01
89 - 123	Bt4	0.15	270.88	8.31	94.12	90.20	37.95	9.87
123 - 151	Bt5C	0.15	237.02	8.21	53.26	64.00	24.53	6.56
Pedon 4 (Balehonnur, Forest)								
0 -15	Ap	2.03	558.69	19.87	148.02	54.33	48.40	17.74
15 -31	Bt1	1.38	406.32	18.89	158.84	60.14	50.16	14.48
31 -58	Bt2	0.83	304.74	18.54	84.74	81.84	35.42	10.67
58 -79	Bt3C	0.42	270.88	17.36	85.7	55.05	31.57	10.66
79 - 115	Bt4C	0.07	287.81	16.46	125.13	48.28	29.92	6.78
115- 151	BC	0.16	274.04	16.02	277.45	66.83	35.97	3.38
Pedon 5 (Madnur, Coconut and field crops)								
0 -20	Ap	0.46	407.4	9.92	347.10	49.80	32.12	10.12
20- 36	Bt1	0.56	323.16	10.02	417.69	45.65	37.07	8.87
36 -90	Bt2	0.34	304.74	9.76	213.22	41.51	35.86	9.12
90 - 109	Bt3	0.16	217.9	8.73	99.53	52.00	44.99	3.44
109 - 129	Bt4	0.15	194.74	8.54	163.77	56.19	49.50	4.65
129 -161	BC	0.07	149.88	7.79	68.05	45.15	36.41	7.65
161 - 180	CB	0.09	122.46	18.9	48.34	49.44	32.12	4.48
Pedon 6 (Salegrama, Forest)								
0 -16	A	1.73	406.32	14.42	397.02	126.28	56.10	12.28
16 -41	Bw1	0.91	372.46	17.32	64.39	173.58	49.61	9.97
41 – 60	Bw2	0.56	338.60	21.12	65.03	144.21	41.25	8.24
60 – 107	Bt1	0.75	304.74	22.24	106.05	201.85	91.19	9.09
107 – 151	Bt2	0.95	287.81	23.12	104.62	259.49	144.21	7.27
151 - 200	BC	0.28	270.88	16.65	154.23	136.84	92.73	7.28
Pedon 7 (Alburu, Areca nut)								
0 -20	Ap	0.85	440.18	27.90	283.97	189.86	63.47	2.15
20 -31	Bt1	0.83	372.46	26.05	218.78	193.38	58.85	9.97
31 - 50	Bt2	0.46	321.67	32.15	140.56	222.97	56.65	7.31
50 - 87	Bt3	0.42	304.74	23.18	174.90	188.21	50.82	8.65
87 - 110	Bt4	0.34	321.67	26.57	134.04	140.80	44.44	10.12
110 - 156	Bt5C	0.42	304.74	24.63	85.22	138.16	36.41	5.59
156 - 185	Bt6C	0.18	304.74	24.57	124.02	290.40	77.00	7.23
Pedon 8 (Alburu, Forest)								
0 -20	A	0.52	406.32	12.19	309.57	78.43	40.37	11.14
20 – 44	Bt1	0.56	372.46	15.34	76.95	155.98	56.87	9.92
44 – 78	Bt2	0.3	255.53	23.43	83.63	193.60	59.73	7.76
78 – 125	Bt3	0.28	172.46	20.05	71.23	169.29	46.64	8.82
125 - 161	Bt4C	0.07	138.6	19.12	94.28	252.12	62.59	4.46
Pedon 9 (Babbur, Coconut and Red gram)								
0 -15	Ap	0.54	406.32	18.35	464.6	376.53	105.6	14.92
15 - 33	Bt1	0.42	338.6	17.87	303.69	474.76	206.25	8.87

33 – 50	Bt2	0.56	270.88	16.45	169.49	547.91	221.54	16.1
50 - 72	Bt3C	0.16	155.81	17.12	87.77	555.18	149.71	15.5
Pedon 10 (Javagamatur, Forest)								
0 -12	A	0.2	204.74	21.34	256.62	162.36	36.63	3.38
12 – 26	Bt1	0.58	270.88	17.70	114.16	308.55	42.79	7.43
26 – 40	Bt2	0.44	213.95	26.67	80.13	447.04	26.51	18.1
40 - 68	BC	0.36	207.02	29.19	65.98	511.61	20.68	5.16

The available sulphur in the soils varied from 3.37 to 17.79 mg kg^{-1} and most of the soils were very low in ratings. Due to higher amount of organic matter in surface layers than in deeper layers, the available sulphur was more in surface horizons than the sub-surface horizons.

Exchangeable calcium and magnesium in all the ten profiles were low to high and ranged from 9.53 to 511.61cmol (p+) kg^{-1} and 6.75 to 224.54 cmol (p+) kg^{-1}respectively, the low calcium and magnesium in hilly and coastal Agro-climatic zones is due to the prevalence of excess and frequent rainfall in the study areas which leached most of the basic cations like calcium, magnesium, potassium and sodium from the surface soil to lower horizons and even high calcium and magnesium in central Agro-climatic zones due low rainfall and accumulation of salts. The clay complex was dominated by exchangeable Ca in surface and sub-surface horizons of most soils followed by Mg. Exchangeable Ca and Mg showed irregular trend with depth of soils.

Conclusions

Nutritional requirement of humanity is primarily met by the produce from agricultural systems. If agricultural systems fail to provide food in required quantity and quality with all the nutrients essential to human life, people will suffer, societies will deteriorate and national development efforts will stagnate. Fertility status of different land use systems of agro-climatic zones of southern Karnataka indicated that soils are low too high in available N and available K and low too high in available P in surface and subsurface horizons. Available Sulphur remained low to medium in most soils. Among the exchangeable bases, exchangeable calcium was found to be high in most soils, followed by magnesium. The deficient nutrients have to be restored through chemical fertilizers and/or organic manures to maintain soil health for efficient and sustainable production in different land use systems in southern agro-climatic zones of Karnataka.

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