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Distribution of Nutrients in Sundarban - A Case study

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Abstrct: The distribution of nutrients were studied in six soil management units *viz.,* Chandipur, Biprodaspur, Pathankhali, Manmathanagar-I, Manmathanagar-II and Bhupendranagar of Gosaba block (part) of sundarban. Data indicated that the soils were strongly acidic (< 4.5) to neutral in reaction and associated with marginal to severe salinity (> 13.3 dS m^{-1}). The organic carbon content ranged from 0.67 to 1.66 per cent in surface and 0.15 to 3.44 per cent in sub-soils. The available nitrogen content varied from 90 to 502 kg ha^{-1} and it changed significantly with depth. The available phosphorus varied from 0.5 to 24.7 kg ha^{-1}. Available potassium and sulphur in soils are very high, ranging from 178 to 572 kg ha^{-1} and 25 to 706 mg kg^{-1} respectively. DTPA -Fe and Mn varied from 18.9 to 336 and 2.17 to 37.6 mg kg^{-1} in soils being higher in sub-surface horizons, and DTPA- Zn and Cu ranged from 0.27 to 4.73 and 0.63 to 14.5 mg kg^{-1} respectively.

Keywords: *Sundarban, acid, salinity, fertility, deficiency and toxicity*

Introduction

The great Sundarbans, the delta region of the river Hooghly, occur in the coastal tracts of West Bengal constitute a major portion of coastal region of India with wide variability in climatic, topographical and edaphic conditions. Coastal ecosystem generally lags much behind the inland areas in terms of crop productivity, mainly because of unfavourable climate, poor soil management and hydrological conditions. The coastal areas are very poor in fertility and the yields are low in these soils unless fertilized regularly. Available macro- and micronutrient status in soil profile help in determining the soils potential to supply nutrients for crop growth and adopt suitable soil and nutrient management in degraded coastal land. The present study was undertaken to make an inventory of nutrients status and distribution in western part of Gosaba block, South 24 Parganas district of West Bengal.

Materials and Methods

Gosaba block is located in the North-Eastern part of South 24 Parganas district, West Bengal and the present study comprises of western part of Gosaba block, comprising of 15 villages and covering an area of 4173 ha (16% of the total geographical area of the block). The soils were developed mainly on alluvial deposits in the delta regions of Hooghly river and on narrow stretches along the sea coast. It has almost flat topography with low elevation (<10 MSL). The climate of the block is sub-tropical, sub-humid with hot humid (AESR18.5) summers and cool winters. The mean maximum and minimum air temperatures are 34.5°C and 18.3°C, respectively. The pre-monsoon starts in April-May and the actual monsoon begins in June which recedes in September of the year. The average annual rainfall is 1400 mm. The soil temperature regime is *hyperthermic* and soil moisture regime is *aquic*.

Detailed soil survey was done on 1: 10,000 scales during April-May, 2014, using IRS-P6 LISS IV with village cadastral map. Profile studies and auger checking were done to cover all the landform units. Six series identified (Chandipur, Biprodaspur, Pathankhali, Manmathanagar-I, Manmathanagar-II and Bhupendranagar). Typical pedon representing identified series were analysed for different parameters. The pH of the soil was determined in 1: 2.5 soils: water solution

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and electrical conductivity of the soil saturation paste (extract) was determined with the help of Wheatstone Conductivity Bridge as described by Jackson (1973). Organic carbon in soil was determined by methods of Nelson and Sommers (1982). Available nitrogen was estimated by following alkaline permanganate method (Subbaiah and Asija 1956). The available phosphorus was extracted using Olsen extractant and then subsequent estimation by chlorostannous reduced molybdophosphoric blue colour method (Jackson 1973). Available potassium was extracted using neutral normal ammonium acetate and measured with flame photometer (Jackson 1973). Sulphur was extracted using 0.15% $CaCl_2$ 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 420 nm of wavelength (Jackson, 1973). Exchangeable calcium and magnesium were determined using versenate (EDTA) titration method. Available micronutrients (iron, copper, manganese and zinc) were extracted using DTPA extract (0.005*M* Diethylene Triamine Penta Acetic acid and 0.01 *M* $CaCl_2$ + 0.1 *N* Triethanolamine at pH 7.3) and the concentration was measured in Atomic Absorption Spectrophotometer (Lindsay and Norvell 1978).

Results and Discussion

The site characteristics, crops and cropping sequence are presented in table 1.

Physico-chemical properties of soils

Soil reaction of the soil was strongly acidic to neutral in nature (Table 2). The pH of soil varied from 4.3 to 5.4 and sub-surface soils from 3.2 to 7.7. Below 100 cm depth soil of Biprodaspur and Bhupendrapur pH is less than 3.5 due to presence of sulphidic materials (Kalyan and Sarkar 2009). Electrical conductivity (ECe) ranged from 1.1 to 10.2 dS m^{-1} in surface and 1.0 to 13.3 dS m^{-1} in sub-soils having irregular distribution with depths. Chandipur and Bhupendrapur soils have more ECe in lower layers. The main factors affecting the salinity in Gosaba block are landform soil type, water quality, water table position, irrigation and land use.

Among the sites, soils of Bhupendranagar series showed comparatively higher organic carbon than others. Organic carbon varied from 0.87 in surface and 0.26 to 1.33 per cent in sub-soils. The differences in organic carbon in lower layers is due to the different strata deposited at different times and half decomposed organic

Table 1. Site characteristics and cropping sequence

Typifying pedon / series	Location	Slope (%)	Drainage	Land use
Chandipur series	22°10' 59.62"N 88°47' 25.82'E	0-1	Imperfectly drained	Paddy- fallow
Biprodaspur series	22°14' 3.68'N 88°47' 42.39'E	0-1	Moderately well drained	Paddy-fallow
Pathankhali series	22°12' 25.95"N 88°45' 33.69'E	0-1	Imperfectly drained	Paddy-fallow
Manmathanagar-I series	22°11' 46.49"N 88°48' 11.02'E	1-3	Moderately well drained	Paddy-black gram
Manmathanagar-IIseries	22°12' 0.71'N 88°48' 21.82'E	1-3	Imperfectly drained	Paddy-chilli
Bhupendranagar series	22°15' 12.75"N 88°48' 53.03'E	0-1	Imperfectly drained	Paddy-vegetables

Table 2. Physico-chemical properties and available macronutrients in coastal soils

Horizon	Depth (cm)	pH (1:2.5)	ECe (dS m^{-1})	OC (%)	Available macronutrients					
					N	P_2O_5	K_2O	Ca	Mg	S
					< ------ Kg ha^{-1} ------>			cmol (p^+) kg^{-1}		mg kg^{-1}
Chandipur series										
Ap	0-15	4.9	10.2	0.90	209	2.51	554	4.0	1.3	269
Bw	15-42	6.3	4.4	0.26	141	3.66	450	4.6	1.3	83
Bwg1	42-62	5.5	5.0	0.23	113	2.51	423	4.2	1.3	173
Bwg2	62-95	4.6	5.5	0.26	130	1.60	453	4.3	1.3	228
Bwg3	95-114	6.3	5.6	0.28	124	9.16	483	4.8	1.3	140
Bwg4	114-130	7.1	4.7	0.24	120	2.74	518	6.1	1.4	140
Biprodaspur series										
Ap	0-16	4.3	8.6	1.51	400	33.3	513	3.7	1.2	611
Bwg1	16-35	4.4	7.4	2.21	293	3.20	560	3.5	1.3	357
Bwg2	35-66	4.2	5.6	1.59	282	1.10	536	3.8	1.2	261
Bwg3	66-89	4.0	9.2	1.90	231	11.9	540	3.5	1.3	430
BC	89-120	3.6	13.3	3.44	383	24.2	686	3.2	1.3	706
Pathankhali series										
Ap	0-17	4.4	4.4	1.66	502	37.5	460	3.6	1.3	151
Bwg1	17-43	4.6	4.0	0.91	180	32.2	472	3.5	1.3	154
Bwg2	43-68	4.4	3.3	0.74	186	24.2	416	2.6	1.3	143
Bwg3	68-87	4.5	3.2	0.24	152	56.5	362	2.8	1.3	77
Bw1	87-120	4.7	2.7	0.15	107	1.83	447	3.4	1.4	103
Bw2	120-145+	5.9	3.9	0.15	90	5.95	517	4.2	1.4	103
Manmathanagar-I series										
Ap	0-16	5.4	1.1	0.67	333	13.5	337	6	1.4	102
Bwg1	16-35	7.0	1.1	0.43	248	32.2	400	7.4	1.6	25
Bwg2	35-66	7.3	1.0	0.43	209	48.3	405	7.0	1.6	52
Bwg3	66-90	5.7	1.5	0.58	265	1.37	326	5.6	1.4	34
Bwg4	90-140	4.5	1.1	0.43	203	2.51	343	3.8	1.3	75
Manmathanagar-II series										
Ap	0-17	4.7	3.5	0.91	412	34.8	340	5.3	1.3	106
Bwg1	17-36	4.6	3.3	0.50	321	49.6	355	5.0	1.3	166
Bwg2	36-56	4.1	5.0	0.67	345	40.3	412	4.8	1.3	253
Bwg3	56-92	4.0	5.4	1.34	416	34.3	399	4.4	1.3	281
Bwg4	92-120	4.1	4.9	0.55	339	28.8	385	4.2	1.2	237
Bw	120-145+	7.7	4.7	0.27	345	25.6	381	7.8	1.5	291
Bhupendranagar series										
Ap	0-13	4.6	2.7	0.87	185	5.95	386	4.2	1.3	103
Bwg1	13-37	6.9	1.2	0.26	156	16.0	325	7.2	1.5	28
Bwg2	37-67	5.3	1.5	0.34	135	11.2	310	5.5	1.3	66
Bwg3	67-101	4.0	3.9	0.97	152	21.5	324	3.2	1.3	287
Bwg4	101-132	3.6	8.5	1.33	230	26.7	213	2.8	1.1	600
Bwg5	132-150	3.2	12.5	0.44	180	2.74	105	3.8	1.2	609

Table 3. Status of available micronutrients in coastal soils

Depth (cm)	Available micronutrients			
	Fe	Mn	Zn	Cu
	< ---------- mg kg^{-1} ---------- >			
	Chandipur series			
0-15	164.6	17.8	1.69	6.57
15-42	27.4	20.3	0.54	2.33
42-62	87.1	8.33	0.77	3.52
62-95	195.6	5.21	0.72	5.0
95-114	68.2	2.17	0.27	2.40
114-130	208.2	29.0	2.56	8.30
	Biprodaspur series			
0-16	25.1	2.96	0.45	1.35
16-35	146.2	33.2	3.08	14.5
35-66	140.3	17.8	2.24	7.82
66-89	141.5	26.5	2.84	9.77
89-120	321.0	28.9	1.56	0.63
	Pathankhali series			
0-17	244.5	18.6	1.36	9.09
17-43	111.8	17.3	1.41	9.30
43-68	152.9	11.4	1.17	7.19
68-87	213.3	8.50	0.85	3.12
87-120	155.9	7.56	0.93	1.58
120-145+	35.9	32.2	1.0	1.44
	Manmathanagar-I series			
0-16	164.7	17.3	0.6	4.80
16-35	34.5	5.04	0.34	4.01
35-66	336.0	3.08	1.0	5.76
66-90	196.0	25.6	1.43	7.32
90-140	141.8	17.5	1.15	5.42
	Manmathanagar-II series			
0-17	225.9	17.0	1.79	5.82
17-36	178.3	10.1	1.43	6.04
36-56	18.9	8.53	1.66	1.66
56-92	115.9	14.3	1.39	6.31
92-120	47.2	15.5	1.13	4.93
120-145+	19.0	18.0	1.66	3.53

matter Soil temperature, precipitation, land management, vegetation and other bio-inputs, biological activity etc. also influence soil organic matter (Bandyopadhyay *et al.* 1998; Zhou *et al.* 2007) in coastal Sundarbans.

Available macronutrients

The distribution of available macronutrients in soils is presented in table 2. The available nitrogen in the soils was rated as low to medium and it varied from 185 to 502 and 90 to 416 kg ha^{-1} in surface and sub-surface layers. Higher availability of N in surface soil is due to addition of excess amount of fertilizer and organic manures. The available phosphorus content in the surface and sub-soils ranged from 1.1 to 16.4 and 0.5 to 24.7 kg ha^{-1} and is rated as low. The availability of phosphorus largely depends on the pH of the soil. Available potassium is very high in coastal soils, ranging from 281 to 462 and 88 to 572 kg ha^{-1} in surface and sub-surface layers respectively. High K in soil is due to the presence of K containing elliptic materials and K containing salts like KCl and K_2SO_4. Coastal saline soils are rich in water soluble, exchangeable, non-exchangeable and available K (Maji and Bandyopadhyay 1991).

Secondary nutrients

The available sulphur in the soils varied from 102 to 611 and 25 to 706 mg kg^{-1} in surface and sub-soils, which is rated as sufficient in all the soils. Biprodaspur and Bhupendrapur soils had higher amount of available sulphur in sub-surface soils compared to surface soil. It is observed that soil containing sulphides (mainly pyrites), which oxidized to sulphates resulting in pH below 4.

Available micronutrients

The distribution of available micronutrients in soils is presented in table 3. The DTPA extractable available Fe and Mn varied from 18.9 to 336 and 2.17 to 37.6 mg kg^{-1}. The higher concentration of Fe and Mn was reported in sub-surface than surface horizons, and has irregular distribution with depth. Higher availability of Fe and Mn in the soils might be due to the waterlogging. The DTPA extractable Zn ranged from 0.6 to 1.79 mg kg^{-1} soil in surface and 0.27 to 4.73 mg kg^{-1} soil in sub-surface horizons. However, increased soil pH enhanced sorption of Zn on the colloidal surface of clay particles with concurrent decrease in their mobility rendering the cations in the soil solution (Das 2000). All the pedons were found to be sufficient in available copper (0.63 to 14.5 mg kg^{-1}) and are above the critical limit of 0.2 mg kg^{-1} as proposed by Lindsay and Norvell (1978). A decreasing trend with depth was noticed in Pathankhali soils and have an irregular trend with depth.

In Sundarban areas, due to poor drainage condition and heavy texture of soil, slightly excess amount of rain or irrigation creates waterlogging in rainy season which results in low soil aeration and higher availability of Fe, Mn and Cu in soil. This causes considerable damage to growing crops and sometimes it may lead to total crop failure (Bandyopadhyay and Sarkar 1987).

Conclusion

In the Sundarbans coastal ecosystem, major constraints for agriculture is soil salinity, nutrient deficiency (N, P and Zn) and toxicity (S, Fe and Mn) are responsible for limiting the crop production. Therefore, it needs to promote the use of fertilizers to correct the deficiency of all these nutrients. Toxicity of some elements is to be controlled by adopting proper drainage system. The other cultural practices like leaching, addition of organic manure, improved fertilizer use efficiency, adopting salinity tolerance plants and other chemical reclamation may enhance crop productivity.

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