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Soil Fertility Status of Some Villages in Khordha and Bhubaneswar Block of Khordha District under North Eastern Ghat Agro Climatic Zone of Odisha, India

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A B S T R A C T

A soil fertility status inventory work was carried out in some villages of Khordha and Bhubaneswar blocks belonging to Khordha district located in the North-Eastern Ghats Agro Climatic Zone of Odisha, India. Results show that soil texture of the villages under investigation varied from loamy sand to clay loam. Clay content varied from 2.4 to 34.0 percent. Soil pH ranged between 4.24 and 6.93 and electrical conductivity of the entire study area remained below 1 dSm^{-1}. Soil Organic Carbon (SOC) content ranged between 1.1 to 11.6 g kg^{-1}. Available nitrogen content in these soils was found to be varying between 50.0 to 225.0 kg ha^{-1}. Available Bray's phosphorus content varied from 11.3 to 2326.5 kg ha^{-1}. Available soil potassium content varied widely from 37.6 to 458.3 kg ha^{-1}. $CaCl_2$extractable soil sulphur varied from 2.17 to 11.02 mg kg^{-1}. Hot water soluble boron content ranged from 0.91 to 2.68 mg kg^{-1}. All the figures in lower range were found in upland soils while the higher values for all the parameters were found in low land soils.

Introduction

Khordha and Bhubaneswar blocks belong to Khordha district which comes under North Eastern Ghat Agro Climatic Zone of Odisha (Nanda *et al*., 2008). As per modern system of soil classification "Soil Taxonomy" the soils of Khordha district are classified under the *Alfisols, Inceptisols and Entisols* (Sahu and Mishra, 2005). Proper application of fertilizers helps in maximizing marketable yields whereas excessive use may be harmful to the environment. Hence, evaluation of soil fertility status of different land types of an area is of primary importance for a balanced application of fertilizers and manures as well as to increase the productivity per unit of cultivable land to cater the growing need of cereals, pulses, oil seeds, fruits and vegetables for the growing population. In the present scenario, soil testing is now considered as an important tool for the recommendation of fertilizer doses for various crops. Again, GPS (Global Positioning System) based soil fertility evaluation not only gives ideas about fertility status of the soil but also helps in monitoring the soil health from time to time.

Focusing on these concepts, four villages of Khordha and Bhubaneswar blocks of Khordha district namely Kuaput, Haladia, Kumvadei and Khatuapadawere selected for studying the GPS based soil fertility status in order to identify the major soil fertility related crop production constraints. Although soil fertility status and maps have been prepared for different blocks of Odisha, but no such intensive work had been done for these villages of the district which have vast areas of agricultural lands. Therefore an attempt was made in the present investigation to prepare soil fertility status of four selected villages of the district. Soils were analysed for some of the basic soil physical and chemical properties which includes mechanical analysis (soil texture), soil pH, EC and SOC. Soil fertility status is evaluated focusing on the most important nutrients for the plant such as nitrogen, phosphorus, potassium, sulphur and boron. This study will help in finding out soil fertility related crop production constraints along with suggesting remedial measures for higher crop production.

Materials and Methods

Experimental site

Out of the four villages under investigation, two villages namely Kuaput and Haladia, are situated in Khordha block (situated at a distance of 15 kms from Khordha - Banki road) and the rest two villages namely Kumvadei and Khatuapada are situated in Bhubaneswar block of Khordha district (situated on the foot hill the famous Dhauligiri hill on both sides of the historic river Daya). Both Dhauligiri hill and Dayariver are associated with Ashoka-the Great because of the Kalinga war.

The mean annual rainfall of the study area is 1597 mm. The mean maximum summer temperature is 37^0C and the mean minimum winter temperature is 10.4^0C. The climate is hot, moist and sub-humid. The soils of this Agro Climatic zone are mostly red loam, brown forest soils (*Haplustalfs, Rhodustalfs, Ustochrepts, Ustorthents)*.

Soil sampling and analysis

The landform of the study area was determined through traversing the area and elevations above MSL of different points were recorded using GPS instrument (Garmin make; model: 76MAPCSx). Total 40 numbers of composite surface (0–15 cm) soil samples were collected from the study area which includes 10 samples from each village from different land types such as upland, medium land and low land. Composite soil samples were collected along with latitude and longitude of the plots with the help of GPS instrument. Soils were analysed for its textural class by Bouyoucos Hydrometer method (Bouyoucos, 1962), pH(1:2) (Jackson, 1973), EC(1:2) (Jackson, 1973), organic carbon (Walkley and Black, 1934) as described by Page *et al*.,(1982), available nitrogen (Subbiah and Asija, 1956), phosphorus (Bray and Kurtz, 1945), potassium (Hanway and Heidel, 1952), sulphur (Chesnin and Yien, 1950), and hot water extractable boron (John *et al*., 1975).

Results and Discussion

Soil texture

The sand, silt and clay content in the soils of Kuaput village were found to vary in between 78.4 to 92.4, 1.6 to 5.2 and 5.3 to 17.4 percent respectively; that of Haladia village varied between 53.4 to 65.8, 7.6 to 14.2 and 23.6 to 34.0 percent respectively; that of Kumvadei varied between 79.0 to 95.4, 2.2 to 10.6 and 2.4 to 11.4 percent respectively; that of Khatuapada village varied between 75.4 to 93.4, 2.0 to 9.2 and 4.4 to 15.4 percent respectively (Table 1). From the Table 1, it is clear that the average clay content increased from upland to low land in all the four villages, which could be attributed to washing away of clay particles from upland and medium land (along with runoff water during heavy rain fall and their subsequent deposition in the low land. Similar findings have also been observed by Nayak (2014) [17], Mishra *et al.*, (2014), Digal *et al.,* (2018) [12] and Dash *et al.*, (2018) [6].

Soil reaction

Soil pH(1:2) of surface soil samples of Kuaput village were found to vary in between 4.6 to 6.1 with a mean value of 5.38; that of soils of Haladia village varied between 5.7 to 6.9 with a mean value of 6.57; that of Kumvadei varied between 4.2 to 6.0 with a mean value of 5.19; that of soils of Khatuapada village varied between 4.9 to 6.1 with a mean value of 5.35 (Table 2). The data showed a gradual increase in soil pH value from upland towards low land, which could be attributed to the removal of basic cations with runoff water from upland and medium land during intensive rainfall and their subsequent deposition in the low land. Hence, the soil acidity appears to be a major crop production constraint in the study area. Similar findings have also been reported earlier by Priyadarshini *et al.*, (2017) andDash *et al.*, (2018).

Electrical conductivity

Electrical Conductivity (1:2) of surface soil samples of the entire study area was found to be less than 1dS m^{-1} (Table 2). Hence, all the soils under the study area are safe for all types of crop production with respect to the soluble salt content.

Organic carbon

Soil Organic Carbon (SOC) of surface soil samples of Kuaput village were found to vary in between 2.3 to 7.6 g kg^{-1} with a mean value of 4.7 g kg^{-1}; that of Haladia village varied between 4.3 to 9.6 g kg^{-1} with a mean value of 7.0 g kg^{-1}; that of Kumvadei varied between 1.1 to 11.6 g kg^{-1} with a mean value of 6.7 g kg^{-1}; that of Khatuapada village varied between 1.2 to 10.7 g kg^{-1} with a mean value of 7.1 g kg^{-1} (Table 2). The results clearly showed a gradual increase in average SOC from upland towards low land surface soil samples which could be attributed to higher cropping intensity aided with more crop residue incorporation in the same. Again, due to higher water table, the oxidation of organic matter is slower in low land areas than that of upland areas. In the entire study area organic carbon status was found to be low to high which enables the soil for growing a wide range of crops. Similar findings have also been reported by Mishra (2013), Digal *et al.*, (2018).

Available nitrogen

Available soil nitrogen content of surface soil samples of Kuaput village were found to vary in between 50 to 188 kg ha^{-1} with a mean value of 123.7 kg ha^{-1}; that of soils of Haladia village varied between 63 to 138 kg ha^{-1} with a mean value of 106.2 kg ha^{-1}; that of soils of Kumvadei varied between 50 to 225 kg ha^{-1} with a mean value of 131.2 kg ha^{-1}; that of soils of Khatuapada village varied between 50 to 225 kg ha^{-1} with a mean value of 118.8 kg ha^{-1} (Table 3). The results clearly showed a gradual increase in average N content from upland to low land which could be attributed to the increased SOC in the low land than that of upland and medium land (as N is released from the soil organic matter by the activity of microorganisms). Available N was found to be positively correlated with organic carbon (r=0.76**) (Table 4). In the entire study area available soil nitrogen content varied between low to medium. Similar results were reported by Behera *et al.,* (2016)

Available phosphorus

Available soil phosphorus content of Kuaput village were found to vary in between 13 to 36 kg ha^{-1} with a mean value of 22 kg ha^{-1}; that of Haladia village varied between 11 to 28 kg ha^{-1} with a mean value of 16.7 kg ha^{-1}; that of Kumvadei varied between 14 to 52 kg ha^{-1} with a mean value of 28.4 kg ha^{-1}; that of Khatuapada village varied between 18 to 90 kg ha^{-1} with a mean value of 50.0 kg ha^{-1} (Table 3).

The results clearly showed a gradual increase in average P content from upland to low land which could be attributed to the increased SOC in the low land than that of upland and medium land (as organic fractions of available phosphorus is mobilized to plant available form by the activity of microorganisms). Available P was found to be positively correlated with organic carbon (r=0.54*) (Table 4). In the entire study area available phosphorus was found within the range of low to high. Similar trends of available P were also observed by Barik *et al.*, (2017).

Table.1 Mechanical composition of soils of the study area

Name of Village	Land Type	% Sand		%Silt		%Clay	
		Range	Mean	Range	Mean	Range	Mean
Kuaput	Upland	91.4-92.4	92.0	2.2-3.2	2.5	5.3-5.6	4.8
	Medium Land	88.2-90.4	88.9	2.2-5.2	4.2	6.6-7.4	6.9
	Low Land	78.4-87.2	83.4	1.6-4.2	3.3	8.6-17.4	13.2
Haladia	Upland	56.8-65.8	60.8	10.6-14.2	12.1	23.6-29.0	27.0
	Medium Land	58.8-60.8	59.4	9.6-11.6	10.8	29.4-30.0	29.6
	Low Land	53.4-56.8	55.4	7.6-12.2	10.3	31.0-34.0	33.0
Kumvadei	Upland	93.4-95.4	94.4	2.2-3.2	2.5	2.4-3.4	3.0
	Medium Land	89.4-91.4	90.2	3.2-5.6	4.7	3.4-7.4	5.0
	Low Land	79.0-87.0	83.1	5.6-10.6	7.5	7.4-11.4	9.4
Khatuapada	Upland	88.4-93.4	91.7	2.0-5.2	3.0	4.4-6.4	5.0
	Medium Land	89.2-93.2	90.6	3.0-3.2	3.0	6.8-7.8	7.3
	Low Land	75.4-87.2	82.0	3.0-9.2	5.9	11.4-15.4	13.6

Table.2 Chemical properties of soils of the study area

Name of Village	Land Type	pH (1:2)		EC (1:2) (dS m^{-1})		OC (g kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean
Kuaput	Upland	4.6-5.1	4.8	0.05-0.06	0.06	2.3-3.2	2.7
	Medium Land	5.1-5.5	5.2	0.06-0.07	0.06	4.0-4.5	4.2
	Low Land	5.6-6.1	5.8	0.07-0.12	0.09	5.4-7.6	6.4
Haladia	Upland	5.7-6.5	6.1	0.05-0.11	0.05	4.3-5.2	4.9
	Medium Land	6.5-6.7	6.6	0.11-0.13	0.12	6.0-6.9	6.3
	Low Land	6.7-6.9	6.8	0.13-0.19	0.15	7.6-9.6	9.0
Kumvadei	Upland	4.2-4.9	5.6	0.01-0.06	0.03	1.1-3.4	1.4
	Medium Land	5.0-5.1	5.1	0.08-0.20	0.13	5.2-9.7	6.9
	Low Land	5.4-6.0	5.7	0.3-0.8	0.53	9.8-11.6	10.5
Khatuapada	Upland	4.9-5.0	5.0	0.01-0.02	0.01	1.2-6.0	4.4
	Medium Land	5.1-5.3	5.2	0.02-0.1	0.05	6.1-7.8	6.8
	Low Land	5.4-6.1	5.7	0.2-0.3	0.23	8.0-10.7	9.4

Table.3 Soil fertility status of the study area

Name of Village	Land Type	Available Nutrient Status									
		N		P		K		S		B	
		(kg ha^{-1})						(mg kg^{-1})			
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Kuaput	Upland	50-100	83	13-18	16	44-64	57	2.7-2.9	2.8	1.34-1.38	1.36
	Medium Land	113-125	121	20-22	20	90-144	116	2.9-3.1	3.0	1.42-1.53	1.47
	Low Land	125-188	156	22-36	28	161-313	208	3.6-5.3	4.1	1.71-2.31	1.99
Haladia	Upland	63-88	71	11-12	12	188-294	240	2.6-3.0	2.9	0.91-1.42	1.10
	Medium Land	11-125	113	13-16	15	327-347	336	3.2-3.4	3.3	1.44-1.49	1.47
	Low Land	125-138	128	18-28	22	351-458	409	3.5-4.8	3.9	1.52-1.77	1.63
Kumvadei	Upland	50-100	79	14-16	15	44-83	62	3.0	3.0	1.35-1.4	1.37
	Medium Land	100-125	113	20-24	21	86-153	129	3.2-3.5	3.4	1.5-1.7	1.61
	Low Land	138-225	184	33-52	43	140-321	208	3.6-11.0	5.8	1.75-2.68	2.33
Khatuapada	Upland	50-100	75	18-30	25	38-81	66	2.1-2.6	2.4	1.30-1.38	1.34
	Medium Land	113	113	37-51	45	90-130	116	2.6-3.3	3.0	1.38-1.43	1.41
	Low Land	125-225	156	57-90	73	132-394	274	3.5-10.4	6.4	1.44-1.51	1.47

Table.4 Correlation between different soil properties

	%Sand	%Silt	% Clay	pH	EC	OC	Av N	Av P	Av K	Av S	Av B
%Sand	1										
%Silt	-0.88**	1									
% Clay	-0.98**	0.80**	1								
pH	-0.92**	0.76**	0.93	1							
EC	-0.14	0.28	0.09	0.29	1						
OC	-0.37	0.36	0.37	0.57*	0.70*	1					
Av N	-0.11	0.14	0.10	0.38	0.76**	0.76**	1				
Av P	0.07	-0.02	-0.04	0.10	0.47	0.54*	0.56*	1			
Av K	-0.83	0.66*	0.86**	0.92**	0.39	0.65*	0.47	0.33	1		
Av S	-0.11	0.14	0.11	0.31	0.71*	0.61*	0.76**	0.79**	0.51*	1	
Av B	0.07	0.01	-0.02	0.22	0.74*	0.58*	0.79**	0.17	0.26	0.52*	1

(*=5% level of significance, **=1% level of significance)

Available potassium

Available soil potassium content of Kuaput village were found to vary in between 44 to 313 kg ha^{-1} with a mean value of 135.3 kg ha^{-1}; that of Haladia village varied between 188 to 458 kg ha^{-1} with a mean value of 336.5 kg ha^{-1}; that of Kumvadeivaried widely between 44 to 321 kg ha^{-1} with a mean value of 140.4 kg ha^{-1}; that of Khatuapada village varied between 38 to 394 kg ha^{-1} with a mean value of 164.0 kg ha^{-1} (Table 3). The results clearly showed a gradual increase in average K content from upland to low land which could be attributed to the increased clay content in the low land than that of upland and medium land (potassium ion being a cation present in the exchange site of negatively charged clay particles). Available K was found to be positively correlated with amount of clay content (r=0.86**) (Table 4). In the entire study area available potassium was found within the range of low to high. Similar results were also observed by Mishra *et al.*, (2017) and Dash *et al.*, (2018).

Available sulphur

Available soil sulphur content of Kuaput village were found to vary in between 2.7 to 5.3 mg kg^{-1} with a mean value of 3.5 mg kg^{-1}; that of Haladia village varied between 2.6 to 4.8 mg kg^{-1} with a mean value of 3.4 mg kg^{-1}; that of Kumvadei varied widely between 3.0 to 11.0 mg kg^{-1} with a mean value of 4.2 mg kg^{-1}; that of Khatuapada village varied between 2.1 to 10.4 mg kg^{-1} with a mean value of 4.2 mg kg^{-1} (Table 3). The results clearly showed a gradual increase in average S content from upland to low land which could be attributed to the increased SOC content in the low land than that of upland and medium land (as S is also released from the soil organic matter by the activity of micro-organisms). Available S was found to be positively correlated with organic carbon (r=0.61*) (Table 4). In the entire study area available sulphur was found to be in the range of low to medium. Similar results were also observed by Nahak *et al.*, (2016) and Mishra (2016).

Available Boron

Hot water extractable boron content of the surface soil samples of Kuaput village were found to vary in between 1.34 to 2.31 mg kg^{-1} with a mean value of 1.65 mg kg^{-1}; that of Haladia village varied between 0.91 to 1.77

mg kg^{-1} with a mean value of 1.42 mg kg^{-1}; that of Kumvadei varied widely between 1.35 to 2.38 mg kg^{-1} with a mean value of 1.83 mg kg^{-1}; that of Khatuapada village varied between 1.30 to 1.51 mg kg^{-1} with a mean value of 1.42 mg kg^{-1} (Table 3). The results clearly showed a gradual increase in average B content from upland to low land which could be attributed to the increased SOC content in the low land than that of upland and medium land. Available B was found to be positively correlated with organic carbon (r=0.58*) (Table 4). In the entire study area available boron was found to be in sufficient range. This type of result is in close conformity with results obtained by Pattanayak (2016).

From the above study it was found that the soils were very-slightly acidic (17%), slightly acidic (13%), moderately acidic (27%), strongly acidic (28%), very strongly acidic (12%) and extremely acidic (3%). SOC content of the study area was found to be high (10%), medium (67%) and low range (23%). Entire study area was found to be low in available nitrogen content (100%). The soil available phosphorus was found to be high (23%), medium (62%) and low range (15%). Available potassium was found to be in low (32%), medium (38%) and high range (30%). Entire study area was found to be low in available sulphur content (100%). Hence, 25 per cent more fertilizers than that of the recommended dose should be applied in the plots having lower range of nutrients. In case of the plots of the farm having higher status of nutrients, 25 per cent less fertilizers than that of the recommended dose should be applied and recommended dose should be applied. In the rest of the plots having medium range, recommended dose of fertilizers should be applied. Since all the plots of the farm were found to lower in available nitrogen and sulphur status, 25 per cent more sulphur containing fertilizers than that of the recommended dose should be applied. In the entire the study area, micronutrient boron was found to be in sufficient range.

In conclusion, soil acidity was found to be the major crop production constraint in the study area. Soils of the entre study area were found to be deficient in available nitrogen and sulphur content. Deficiency of phosphorus and sulphur were also noticed in many of the plots. Soil erosion and water logging were found to be the major constraints in upland and low land respectively. So, application of liming materials along with application of soil test based fertilizers will help to obtain higher crop production. Application of organic manures along with the inorganic will not only help in enriching the soils with organic matter but also will be a key for sustaining soil health and quality.

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