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Soil Fertility Status of Some Villages under North-Eastern Coastal Plain Agroclimatic Zone of Odisha

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A soil fertility status inventory work was carried out in few villages of Salepur block of Cuttack district. Results show that soil texture of the villages under investigation varied from sandy loam to clay loam and soil colour lies within brown to yellow. Clay content in all the soils varied from 8.8 to 28.8 percent. Soil pH value ranged between 5.13 and 6.63 and electrical conductance remained <0.14 dSm^{-1}. Soil organic carbon (SOC) content ranged between 2.8 to 10.6 g kg^{-1}. Available nitrogen content in these soils was found to be low as it ranged between 112.5 and 237.5 kg ha^{-1}. Available phosphorus (P_2O_5) content varied widely from 4.0 to 146.9 kg ha^{-1}. Available soil potash (K_2O) content varied from 32.3 to 376.3 kg ha^{-1}. $CaCl_2$ extractable soil sulphur varied from 0.95 to 10.9 mg kg^{-1} rendered the soils deficient in S. Hot-water soluble boron content ranged from 0.06 to 2.28 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. There was an increasing trend of soil reaction, SOC, N, P, K, S and B from upland to lowland because of washing down of basic cations, organic matter and plant nutrients from uplands and subsequent deposition in low lands. Clay content was found to be positively correlated with all the parameters under investigation. Significant positive correlation among different parameters was found except sand which showed negative correlation with all the parameters.

(***Key words***: *Available nutrients, Odisha, Physico-chemical properties, Soil fertility*)

Cuttack district is one of the oldest districts of Odisha located at 20° 31′ 23″ N and 085° 47′ 17″ E with a total geographical area of 3932 km^2. The study areas come under north eastern coastal plain agro climatic zone of Odisha having moist sub humid climate with an average annual rainfall of 1568 mm. The Mahanadi is the major river which traverses Cuttack district in east-west direction. Soils are classified under the order *Inceptisol* and *Entisol* (Mishra and Sarangi, 2013). Sound knowledge about soil fertility status is very much relevant for identifying constraints in crop husbandry for attaining sustained productivity and facilitating agro technology transfer programme. Availability of nutrients in soil is influenced by their distribution in soil and other physico-chemical characteristics. A soil resource inventory study provides detail information of its potentialities and limitations for its effective management (Manchanda *et al*., 2002). The detail soil fertility status inventory work in Salepur district of Cuttack has not been done extensively. Keeping the above facts in view a soil resource inventory work was undertaken to study the soil fertility status of few villages of Salepur block in Cuttack district, Odisha to generate information on soil fertility status which may provide a basis for implementing the advanced technologies to achieve sustainable crop production with higher profitability.

MATERIALS AND METHODS

Surface (0-15 cm) soil samples were collected from the selected villages namely, Banahara, Pikola and Barada of Salepur block of Cuttack district. The collected soil samples were processed and analyzed in the laboratory. Soil reaction and electrical conductivity were measured by preparing soil:water suspension at 1:2 ratio. The pH of soil-water suspension was measured by pH meter and electrical conductivity of the supernatant soil-water suspension was taken in conductivity meter. A known amount soil sample was oxidized with 1N potassium dichromate solution and left over potassium dichromate solution was titrated against 0.5 N ferrous ammonium sulphate using Ferroin indicator for determination of oxidisable organic carbon (Walkley and Black, 1934). Available soil nitrogen content was determined by distillation of soil sample with $KMnO_4$ and NaOH solutions using boric acid trap as explained by Subbiah and Asija, 1956. Bray's No. 1 extractant

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(0.3N NH_4F and 0.025 N HCl) was used for determination of available soil phosphorus content. Neutral normal ammonium acetate solution was used as extracting agent for determining the potassium content in soil (Hanway and Heidel, 1952). Available ($CaCl_2$ extractable) soil sulphur (Chesnin and Yien, 1950), hot water-soluble boron (John *et al*., 1975), soil colour (by using Munsell colour chart) and textural class (Bouyoucos, 1962) were also determined. The analytical methods were followed as per the procedure laid down by Jackson (1973).

RESULTS AND DISCUSSION

The results of various physico-chemical properties, major nutrients, secondary and micro - nutrients are presented in Tables 1, 2, and 3. A correlation study on different soil parameters are presented in Table 4.

Physico – chemical properties

Soil colour of Banahara village ranged within olive brown, grayish brown and yellowish brown. In Pikola village, soil colour varied from yellowish brown to reddish yellow and in Barada village it came under brownish yellow to yellow in colour.

Soil texture of Banahara village varied between loamy sand to clay loam whereas in Pikola village it remained within loamy sand to sandy loam and in Barada village it remained within sandy loam to sandy clay loam. Higher amount of clay content was found in lowland as clay particles were washed down from the up and medium land with runoff water and subsequent deposition in the low land because of the pedogenic process of *colluviation*. Similar findings have been observed by Nayak *et al.* (2015) and Satpathy *et al.* (2015).

Surface soils of Banahara village were slightly acidic to acidic which varied from 5.35 to 6.01 (Table 1). In Pikola, soil pH varied from 5.13 to 6.63 which came under acidic to neutral in reaction. Similarly, in Barada, soil pH varied from 5.17 to 5.64 which indicated the soils ranged from slightly acidic to acidic. Comparing all the soils under investigation, Barada village were more acidic in reaction than Banahara and Pikola. The results clearly indicated that lower pH values (acidic) were observed in upland soils and higher pH value towards neutral were observed in low land soils of the study area. Soil pH was significantly and negatively correlated with sand ($r = 0.65^*$) but positively with silt ($r = 0.60^*$), clay ($r = 0.64^*$), OC ($r = 0.77^{**}$), N ($r = 0.76^{**}$), K ($r = 0.71^*$), S ($r = 0.48$) and B ($r = 0.63^*$). Similar findings have been observed by Behera *et al*. (2016). Electrical conductivity (EC_2) value of all the soils remained within the safe limit for crop production as it was found < 0.14 dSm^{-1}.

In Banahara, SOC content varied from 3.8 to 10.6 g kg^{-1}. Similarly, in Pikola mean SOC content varied between 4.2 and 7.8 g kg^{-1}. Whereas, in Barada, mean SOC content varied from 2.8 to 8.1 g kg^{-1}. Higher SOC content in low land soils of all the villages were observed as the lower lands received runoff washing of upland and a medium land soils. SOC was negatively correlated with sand ($r = 0.80^{**}$) but positively correlated with available N ($r = 0.83^{**}$), P ($r = 0.83^{**}$), K ($r = 0.87^{**}$). Similar finding was reported earlier by Nayak *et al.* (2015).

Major nutrients

The increasing trend in average soil nitrogen content was observed in all the villages from upland to lowland. It is known that there is existence of close relationship between organic carbon and available nitrogen in soil. Therefore, soils of low land were found with more N in comparison to the medium land. Likewise, medium land retained more nitrogen in comparison to soils of upland. Soil available nitrogen was negatively correlated with sand ($r = 0.79^{**}$) but positively correlated with P ($r = 0.93^{**}$), K ($r = 0.86^{**}$), S ($r = 0.77^{**}$) and B ($r = 0.71^{**}$). Similar findings were observed by Behera *et al*. (2016) and Satpathy *et al*. (2015).

Results show that P_2O_5 content (Bray's P) in all the soils of Banahara village varied from 21.1 to 146.9 kg ha^{-1} which showed medium to high in P content. Soils of Pikola village were found to be low in available P_2O_5 content (4.0 to 14.4 kg ha^{-1}). Similarly, in the soils of Barada, P content was found in low to medium range. Mean available P_2O_5 content in soils of all the villages was found to be increasing from upland to lowland. Comparatively higher value of available phosphorus in low land soils can be attributed to the higher content of SOC in low land as phosphorus is released from the organic matter slowly. Available Soil phosphorus is negatively correlated with sand ($r = 0.87^{**}$) but positively correlated with OC, N, K, S and B (Table 4). Similar findings have been observed by Behera *et al.* (2016) and Satpathy *et al.* (2015).

The upland and medium land soils of Banahara village were low to medium (114.3 to 216.4 kg ha^{-1}) in K content whereas, in low land soil it remained in medium range (216.4 to 376.3 kg ha^{-1}). In Pikola village K content in upland soil was very low (32.3 to 94.1 kg ha^{-1}) but in low land soil it remained within medium range (111.6 to 196.2 kg ha^{-1}). Irrespective of land types, soils

Table 1. *Soil physico – chemical properties and fertility status of Banahara village, Salepur block of Cuttack district*

Land Type	Soil Colour	Soil Texture	pH (1:2)	EC_2 (dSm^{-1})	OC ($g\ kg^{-1}$)	Major nutrients ($kg\ ha^{-1}$)			Secondary and Micro nutrients	
						N	P_2O_5	K_2O	S ($mg\ kg^{-1}$)	B ($mg\ kg^{-1}$)
Up Land	Olive brown	Loamy sand	5.35	0.032	3.8	137.5	21.1	114.3	0.95	0.06
Up Land	Grayish brown	Sandy loam	5.41	0.071	5.8	137.5	36.1	173.4	1.04	0.18
Up Land	Light olive brown	Sandy loam	5.43	0.077	6.0	137.5	46.4	189.5	1.39	0.24
Medium Land	Yellow	Sandy loam	5.55	0.080	7.2	162.5	58.7	196.2	2.08	0.30
Medium Land	Yellowish brown	Sandy loam	5.61	0.093	7.8	162.5	66.4	198.9	2.69	0.30
Medium Land	Light yellowish brown	Sandy loam	5.65	0.097	7.9	162.5	69.0	216.4	3.91	0.42
Low Land	Light yellowish brown	Clay loam	5.85	0.106	9.3	175.0	101.9	216.4	4.17	0.66
Low Land	Light yellowish brown	Clay loam	5.92	0.108	9.8	200.0	135.9	255.4	4.61	0.78
Low Land	Light yellowish brown	Clay loam	5.93	0.121	10.2	212.5	138.9	301.0	10.2	1.02
Low Land	Light yellowish brown	Clay loam	6.01	0.142	10.6	237.5	146.9	376.3	10.96	1.38

Table 2. *Soil physico – chemical properties and fertility status of Pikola village, Salepur block of Cuttack district*

Land Type	Soil Colour	Soil Texture	pH (1:2)	EC_2 (dSm^{-1})	OC ($g\ kg^{-1}$)	Major nutrients ($kg\ ha^{-1}$)			Secondary and Micro nutrients	
						N	P_2O_5	K_2O	S ($mg\ kg^{-1}$)	B ($mg\ kg^{-1}$)
Up Land	Yellowish brown	Loamy sand	5.13	0.024	4.2	112.5	4.0	32.3	1.30	0.12
Up Land	Brown	Loamy sand	5.29	0.040	4.3	112.5	8.7	60.5	1.39	0.18
Up Land	Brown	Sandy loam	5.31	0.054	4.7	125.0	10.3	63.2	1.91	0.12
Medium Land	Reddish yellow	Sandy loam	5.34	0.086	5.8	125.0	9.8	87.4	2.17	0.12
Medium Land	Reddish yellow	Sandy loam	5.46	0.067	6.8	125.0	14.4	94.1	2.78	0.18
Medium Land	Reddish yellow	Sandy loam	5.77	0.0092	7.6	137.5	14.4	94.1	2.95	0.30
Low Land	Yellowish brown	Sandy loam	5.93	0.093	7.8	137.5	27.3	111.6	3.29	0.48
Low Land	Brown	Sandy loam	6.34	0.095	7.8	150.0	61.8	154.6	3.13	0.84
Low Land	Brownish yellow	Sandy loam	6.09	0.108	7.8	150.0	69.6	161.3	3.74	1.32
Low Land	Brownish yellow	Sandy loam	6.63	0.107	7.8	237.5	109.7	196.2	4.43	1.80

***Table 3.** Soil physico – chemical properties and fertility status of Barada village, Salepur block of Cuttack district*

Land Type	Soil Colour	Soil Texture	pH (1:2)	EC_2 (dSm^{-1})	OC ($g\ kg^{-1}$)	Major nutrients ($kg\ ha^{-1}$)			Secondary and Micro nutrients	
						N	P_2O_5	K_2O	S ($mg\ kg^{-1}$)	B ($mg\ kg^{-1}$)
Up Land	Yellow	Sandy loam	5.17	0.034	2.8	100.0	10.9	40.3	1.74	0.12
Up Land	Light yellowish brown	Sandy loam	5.23	0.037	3.9	100.0	11.4	51.1	2.87	0.12
Up Land	Very pale brown	Sandy loam	5.32	0.042	3.8	112.5	20.6	52.4	2.61	0.24
Medium Land	Yellow	Sandy loam	5.36	0.047	3.9	125.0	20.3	67.2	2.87	0.30
Medium Land	Yellow	Sandy loam	5.29	0.047	4.2	137.5	27.3	69.8	2.95	0.36
Medium Land	Yellow	Sandy loam	5.37	0.049	4.3	137.5	43.3	86.0	3.30	0.30
Low Land	Brownish yellow	Sandy loam	5.37	0.062	4.7	150.0	41.7	90.0	3.65	0.48
Low Land	Brownishyellow	Sandy loam	5.40	0.083	5.7	137.5	46.4	111.5	3.82	1.14
Low Land	Brownish yellow	Sandy clay loam	5.57	0.056	6.2	150.0	60.8	102.1	4.08	1.44
Low Land	Brownish yellow	Sandy clay loam	5.64	0.124	8.1	187.5	64.4	125.0	8.61	2.28

of Barada village had very low K content (40.3 to 124.9 kg ha^{-1}). Mean available soil potassium content in all the villages were found to be increasing according to land situation from upland to lowland. Comparatively higher content of potassium was observed in the lowland soils owing to the presence of higher content of clay in the lowland surface soil. Available soil potassium was found to be correlated negatively with sand but positive correlation was found with pH (r = 0.58*), OC (r = 0.91**), N (r = 0.87**), P_2O_5 (r = 0.71*), S (r = 0.82**) and B (r = 0.75*). Though there is no direct relationship between organic carbon and potassium release in soil, still the present study showed significant positive correlation. This can be attributed to washing out of K along with other basic cations and organic matter by leaching and surface runoff of water from upland which were deposited in low lying areas. Similar findings were reported by earlier workers (Behera *et al.*, 2016; Mishra *et al.*, 2016 and Satpathy *et al.*, 2015).

Secondary and micro nutrients

The results showed that, almost all the soils under investigation were low in S content which can limit the crop production specially oilseed crops. Comparatively higher amount of available S was found in low land soils. Low concentration of sulphur in upland soil may be characterized by the leaching or surface runoff loss and subsequent accumulation of sulphur in low land (Paul and Mukhopadhyay, 2014). Higher amount of available sulphur in low land soils are associated with the organic C content as S is mineralized from the organic matter (Das *et al.,* 2012). Similar findings have been reported earlier by Behera *et al.* (2016) and Mishra *et al.* (2016). Correlation study (Table 4) showed that available soil sulphur was negatively correlated with sand (r = 0.81) but positively correlated with clay (r = 0.83**), OC (r = 0.69*), N (r = 0.77**), P_2O_5 (r = 0.75), K (r = 0.67*) and B (r = 0.71*) (Table 4). Similar significant positive correlation of S was also observed by Ali *et al.* (2014) and Das *et al.* (2012).

Mean hot water-soluble boron content in soils was found to be increased from upland to lowland. Higher content of B was found in low land soils compared to the soils under upland and medium land. This might be attributed to the higher amount of OC present in low land soils which are resultant effect of washing down of B from up and medium lands. Hot water soluble boron was found to be positively correlated with clay (r = 0.71*), pH (r = 0.63*), OC (r = 0.55*), N (r = 0.71*), P_2O_5 (r = 0.63*), K (r = 0.43) and S (r = 0.71*) but negatively correlated with sand (r = 69). Similar findings were

***Table 4**. Correlation between different physico-chemical properties*

	Sand	Silt	Clay	pH	EC	OC	N	P_2O_5	K_2O	S	B
Sand	1.0										
Silt	-0.92**	1.0									
Clay	-0.98**	0.83**	1.0								
pH	-0.65*	0.60*	0.64*	1.0							
EC	-0.75**	0.71*	0.73*	0.67*	1.0						
OC	-0.82**	0.77**	0.80**	0.77**	0.82**	1.0					
N	-0.79**	0.69*	0.80**	0.76**	0.81**	0.83**	1.0				
P_2O_5	-0.87**	0.76**	0.88**	0.71*	0.82**	0.83**	0.93**	1.0			
K_2O	-0.73*	0.65*	0.72*	0.64*	0.82**	0.87**	0.86**	0.91**	1.0		
S	-0.81**	0.67*	0.83**	0.48	0.69*	0.68*	0.77**	0.75**	0.67**	1.0	
B	-0.69*	0.57*	0.71*	0.63*	0.65*	0.55*	0.71*	0.63*	0.43	0.71*	1.0

(Significant at ** 1% and * 5% level)

observed by Behera *et al*., (2016) and Mishra *et al*., (2014).

CONCLUSION

The present study reveals that low land of each village studied had neutral soil pH, higher in organic carbon, N, P, K, S and B. Among the villages, Banahara soil has highest content of organic carbon, N, P, K, S and B followed by soils of Barada and Pikola. The study helps to build up the database on physico – chemical properties along with available nutrient status of the study area which may be useful for evaluation, planning and monitoring of soil fertility status for balanced recommendation of fertilizer.

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