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Fertility Status of Rice Growing Soils Belonging to Different Land Types Under the Western Central Tableland Agro-climatic Zone of Odisha

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ABSTRACT

We evaluated the fertility status of rice growing soils under three land types, i.e. upland, medium land and lowland. Composite soil samples were collected from 74 different locations covering the three land types. Results showed that the soils of upland were low in available nutrient (N, P, K and S) contents and the soils of lowland had comparatively higher contents of available nutrients; whereas soils under medium land were found to be intermediate in available nutrients. The soils were moderately acidic to neutral in reaction. Soil organic carbon (SOC) content showed wide variations, being high in lowland soils whereas the upland soils were low in SOC content. Considering all the seventy four samples tested, dynamic relationships were found between available nutrient content and SOC content. Soil pH also maintained excellent agreement with available nutrient content and SOC content. Findings from the above study will be helpful in formulating a sound fertilization program in this area for the economic benefits of farmers.

Key Words: Available Nutrient Contents; Fertility Status; Fertilization Program; Land Types; Soil pH

INTRODUCTION

Soil fertility management and restoration has been a major problem to crop production, varying considerably across agro-ecological zones within the country. Nitrogen, phosphorus, potassium and sulphur are essential nutrient elements in soils that control its fertility and yields of crop (Singh and Mishra, 2012). Rice is mostly grown in lowland soils but also cultivated in medium land and upland soils to some extent. Increase in rice yield is likely to occur through fine-tuning of soil-crop-nutrient management. Inadequate nitrogen supply in soils commonly limits grain yield in irrigated rice systems. The demand of rice plant for other macro-nutrients mainly depends on the N supply (Dobermann et al. 1998). On the other hand, the average plant recovery of fertilizer N is only about 30% (Dobermann, 2000), although much knowledge has been gained about the nitrogen cycle in lowland rice environments. Application of other macronutrients such as potassium has lagged behind, leading to imbalanced plant nutrition and negative potassium input-output balances in many parts of Asia (Dobermann et al. 1998). Due to negative nutrient balances, significant depletion of soil nutrients such as P or K seems to occur in irrigated rice areas of tropical Asia (Dobermann et al. 1996).

Characterization of soils for evaluation of its fertility status in an area is an important aspect in the context of sustainable agricultural production. Variation in nutrient supply in soils is a natural phenomenon and some of the areas may be sufficient where others are deficient. Most of the soils seem to be deficient in one or more plant nutrients because of the continous nutrient mining through intensive cultivation pattern and growing of high yielding crop varieties. Deficiencies of major plant nutrients N, P and K has been well established but their excessive application particularly of N has disturbed the balance of other macro and micronutrients in soils. Also the defieciency of secondary plant nutrient sulphur is at par with N, P and K. Sulphur deficiency is widespread all over the world (Scherer 2009) due to intensive cultivation of high sulphur demanding crops and incidental application of sulphur fertilizers as impurities along with N, P and K fertilizers. The problem of stagnant or even decreasing trend of crop yield is further aggravated due to faulty management of fertilizer. The stagnation in crop productivity cannot be boosted without judicious use of macro and micro-nutrient fertilizers to overcome existing deficiencies/ imbalances.

The soils under different land types subjected to various physic-chemical changes with due course of time owing to diverse environment for rice cultivation. The nutrient dynamics for lowland will be different from that of upland and medium land. Lowland soils remain submerged during growing season of rice crop which influences the nutrient availabilty in soils for crop growth. Under certain specific situation, the availability of nutrients in soils is affected by pH, organic matter content, clay content and various oxidation-reduction reactions (Das 2011.). Moreover, with the intensive fertilization of soils, it is likely that some physiological, nutritional imbalance in plants may arise due to lower uptake of indigenous nutrients or their reduced translocation within the plants. In this regard reports on the available nutrient status in soils of the study area is scanty.

Therefore an attempt was taken to evaluate the status of available macronutrients especially N, P, K and S in soils and also their relationships with physic-chemical properties of soils.

MATERIALS AND METHODS

The study area is located at Saharapali village of Bargarh distirct which falls under the Western central table land agro-climatic zones of Odisha (CES 2016). It lies between 21^0 33' N and 83^0 62' E which is 15 km away from the city. The soils are mostly mixed red and yellow type (Haplustalfs, Paleustalfs and Ustochrepts). The mean annual rainfall of the area is around 1350 mm and the mean annual temperature remains around 30-35^{0}C.

Composite soil samples (0-20cm) were collected from three different land type i.e. upland, medium land and lowland in the study area. The lands are classified based on field hydrology and soil type. Lowlands are located in lower toposequence of fields and well suited for rice cultivation. Uplands are located in the upper fields with less moisture availability and rice is grown where assured irrigation is available. Medium land is intermediate between upland and lowland. For the present study, twenty five (25) soil samples from upland, twenty three (23) from medium land and twenty six (26) from lowland were collected in the year 2015.

Soil samples were air dried, processed to pass through 2mm sieve and analyzed for different soil properties following standard protocols. Organic carbon was determined by the wet oxidation method of Walkley and Black (1934). Available nitrogen (0.32% alkaline $KMnO_4$), phosphorus (0.5M $NaHCO_3$) and potassium (1N NH_4OAc) were determined following the methods outlined by Jackson (1973). Available sulphur (0.15% $CaCl_2$ solution) was determined by turbidimetric method as described by Chesnin and Yien (1950).

Correlation matrix between available macro-nutrients and physic-chemical properties of soils was drawn with the help of SPSS version 20.0 software.

RESULT AND DISCUSSION:

Soil pH

The pH of soils varied from slightly acidic in the upland soils to neutral in lowland soils. Soils of medium land were moderately acidic in reaction. Reports were also there that about 69% of arable land of Odisha are acidic and around 25% lands are neutral in reactions (Satpathy et al. 2015). The pH of upland, medium land and lowland ranged from 4.78- 6.42, 5.48- 6.51 and 6.45-7.45 with mean values 5.95, 6.10 and 6.87 respectively (Tables1, 2 and 3). The lower pH in upland soils could be due to well oxidized surface layer of the soils resulting productions of H^+ ions during oxidation of different elements. Leaching and runoff loss of basic nutrients from upland soils also lead to reduction in soil pH. In lowland rice soils due to submergence, the soils get reduced leading to consumption of H^+ ions in the system with concomitant rise in soil pH (Das 2011). Rise in pH of lowland rice soils were also reported to be due the accumulations of basic leached materials from upland soils. Soil pH maintained significant positive correlations with available nutrients (N, P, K and S) and soil organic carbon (SOC) content of soils (table.4).

Soil Organic Carbon (SOC) Content

Soil organic carbon content is often reported to be the most important attribute in maintaining soil health as it

Table1. Soil properties and available nutrient status (N, P, K & S) in Upland soils

Sample	pH	SOC (g kg^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})
1	4.89± 0.04	2.5± 0.35	187.5± 2.64	7.5± 0.30	110.4± 1.91	8.4± 0.20
2	4.78± 0.07	2.8± 0.31	192.2± 3.26	8.3± 0.25	107.8± 2.88	7.8± 0.30
3	5.84± 0.05	2.7± 0.21	182.3± 4.25	9.0± 0.47	98.8± 3.47	9.5± 0.26
4	5.26± 0.03	2.6± 0.21	215.7± 4.92	9.2± 0.25	103.0± 4.00	10.5± 0.70
5	5.83± 0.08	3.0± 0.15	220.6± 5.38	10.0± 0.25	87.9± 7.97	9.6± 0.55
6	6.37± 0.04	2.8± 0.20	183.0± 5.75	9.8± 0.25	88.1± 5.11	9.2± 0.45
7	6.23± 0.05	3.1± 0.25	192.3± 3.90	7.3± 0.32	84.5± 5.28	9.7± 0.50
8	6.16± 0.05	3.8± 0.17	193.2± 4.83	7.7± 0.50	88.1± 5.00	9.3± 0.56
9	6.42± 0.08	3.5± 0.30	217.4± 4.48	8.5± 0.35	105.4± 4.55	9.3± 0.32
10	6.39± 0.03	3.5± 0.25	198.7± 7.11	8.5± 0.35	87.4± 5.05	9.2± 0.36
11	6.26± 0.03	2.5± 0.21	196.1± 5.51	9.2± 0.36	88.5± 1.93	8.9± 0.35
12	6.04± 0.06	2.4± 0.25	193.0± 3.44	7.8± 0.60	101.5± 4.29	8.8± 0.78
13	6.06± 0.04	2.6± 0.25	186.0± 3.60	9.1± 0.40	98.3± 5.36	8.1± 0.38
14	6.28± 0.07	2.4± 0.40	199.9± 1.95	9.1± 0.31	107.1± 4.15	9.6± 0.47
15	4.90± 0.05	3.3± 0.21	218.9± 6.56	9.0± 0.36	100.2± 2.65	9.7± 0.50
16	5.73± 0.07	3.7± 0.50	211.0± 5.26	8.6± 0.46	93.0± 3.60	10.0± 0.31
17	5.74± 0.11	2.1± 0.35	210.4± 5.51	9.2± 0.32	89.7± 2.51	8.9± 0.50
18	5.93± 0.05	2.5± 0.31	216.8± 4.66	9.5± 0.40	84.2± 5.11	9.3± 0.40
19	6.29± 0.05	2.4± 0.30	193.3± 3.55	9.7± 0.42	101.8± 3.04	9.7± 0.53
20	6.27± 0.06	3.4± 0.21	214.0± 1.19	7.5± 0.35	114.7± 4.22	9.7± 0.47
21	6.17± 0.05	2.8± 0.10	192.8± 3.56	9.0± 0.26	109.8± 7.16	10.2± 0.40
22	5.89± 0.04	3.0± 0.12	187.5± 4.38	9.5± 0.25	102.1± 3.61	10.1± 0.31
23	6.37± 0.05	2.5± 0.23	197.9± 3.85	10.4± 0.21	110.1± 3.46	8.3± 0.61
24	6.28± 0.05	3.3± 0.26	222.1± 4.88	11.5± 0.32	113.8± 6.01	9.6± 0.51
25	6.32± 0.04	2.9± 0.25	211.4± 4.95	12.1± 0.30	112.5± 6.10	11.6± 0.45
Range	4.78- 6.42	2.1- 3.8	182.3- 222.1	7.3- 12.1	84.2- 114.7	7.8- 10.5
Mean	5.95	2.9	201.4	9.1	99.6	9.4
SD	0.49	0.5	13.0	1.2	10.0	0.8

influences the physical, chemical and biological properties of soils. The results presented in Tables 1-3 reveal that the SOC content was moderate although some of the upland soils had low SOC content. The SOC (g kg^{-1}) ranged from 2.1- 3.8, 2.6- 5.5 and 3.5- 6.3 with mean values 2.9, 3.8 and 4.6 g kg^{-1} in upland, medium land and lowland soils, respectively. The higher rate of oxidaton could be the reason for lower content of SOC in upland soils whereas higher content of the same in lowland soils could be due to the prevailing reduced conditions and lower aerobic microbial activity leading to intermediate stage of decompostion of organic matter. Higher content of SOC in lowland soils compared to upland and medium land soils of Nimapara block of east and south-eastern coastal plain agro-climatc zones of Odisha was reported by Satpathy et al. (2015). Table.4 shows that SOC content is significantly positively correlated with soil pH and available nutrient contents.

Available Nitrogen

The available nitrgoen content (kg ha^{-1}) ranged from 182.3 to 222.1 (mean value 201.4), 183.7 to 242.7 (mean 218.2) and 218.7 to 294.2 (mean 265.8) in upland, medium land and lowland rice soils, respectively. Results depicted in table.1, 2 &3 showed that the soils were low in available nitrogen content. Since organic matter content is an indicator of available N status of soils, the soils of the area were also dominantly low in respect of their available N. Similar results were reported by Kumar et al. (2014) and Satpathy et al. (2015). Poor content of SOC and limited addition of nitrogen through external sources have made the upland soils poor in available nitrogen content. It is also quite obvious that being highly mobile available nitrogen content in upland soils is low. Available nitrogen content maintained significant positive correlation with the SOC content

(0.550**). Similar result reported by Mishra (2005), Nayak (2013), Swain (2013) and Kumar et al. (2014). Lowland rice soils had higher available nitrogen content than in upland and medium land soils possibly because of the higher SOC content. Such magnitude of available nitrogen in lowland rice soils of Nimapara block of east and south-eastern coastal plain agro-climatic zones of Odisha were reported by Satpathy et al. (2015).

Available Phosphorus

Phosphorous (P) is present in soil as solid phase with varying degree of solubility. When water soluble P is added to the soil, it is converted to insoluble solid phase by reacting with Ca and Mg ions and also partly with soil organic matter (Olsen 1953). These reactions affect the availability of P in soils and result a very small amount of available P in soil solution. The mean available P (kgha^{-1}) content was lower in upland (9.1) and medium land (12.6) soils compared to lowland (17.7) rice soils. The study indicated that majority of the sampled areas were under the medium range of available P content. The lower availability of P in upland soils may be due to the fixation of phosphate on the positive charge of soil colloids developed due to lower pH value. On the other hand, the increased availability of P in lowland rice soils is due to soil submergence which strongly influences the P availability in soils. Upon submergence of soils, the adsorbed P on positive sites of soil colloids released into soil solution due to the rise in soil pH resulting the increased availability of P in soils which was in accordance with the findings of Desta (2015). Organic anions released from the decomposition of soil organic matter (SOM) in lowland soils could be another reason for increased availability of P in such soils as strong competition between phosphate and organic anions for the same binding sites in the soil colloids (Asmare 2014, Desta 2015). Nayak (2013) and Swain (2013) also reported that organic matter addition improves the P availability in soils through a slow process.

Table2. Soil properties and available nutrient status (N, P, K & S) in Medium land soils

Sample	pH	SOC	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})
26	5.48± 0.07	3.5± 0.31	237.3± 2.44	10.4± 0.21	110.6± 1.95	9.2± 0.65
27	5.80± 0.05	4.3± 0.26	220.7± 1.85	10.5± 0.36	108.1± 2.59	9.0± 0.57
28	6.36± 0.06	3.7± 0.21	221.7± 4.24	10.4± 0.40	111.0± 1.40	10.5± 0.31
29	6.26± 0.05	3.5± 0.31	183.7± 7.58	12.4± 0.31	126.7± 5.28	11.9± 0.30
30	6.22± 0.06	3.0± 0.21	177.9± 2.65	11.5± 0.51	121.9± 2.39	12.2± 0.42
31	6.01± 0.03	3.3± 0.25	242.7± 2.80	11.5± 0.31	124.3± 4.05	14.0± 0.53
32	5.78± 0.07	2.8± 0.25	233.1± 4.12	14.9± 0.35	122.0± 3.01	13.5± 0.30
33	5.73± 0.04	4.1± 0.15	237.0± 4.10	14.1± 0.49	118.7± 2.69	12.5± 0.40
34	5.73± 0.10	5.0± 0.32	197.4± 5.05	14.3± 0.35	118.6± 1.92	11.5±03.0
35	6.16± 0.05	4.5± 0.31	205.7± 4.56	13.5± 0.26	121.6± 2.80	12.4± 0.35
36	6.51± 0.03	4.6± 0.42	208.0± 4.98	15.1± 0.21	124.5± 2.05	10.1± 0.42
37	6.20± 0.02	5.5± 0.30	224.0± 5.28	14.2± 0.36	124.6± 3.43	10.4± 0.32
38	6.42± 0.03	5.3±0.15	228.0± 7.51	12.7± 0.50	127.7± 5.03	11.5± 0.26
39	6.35± 0.03	3.5± 0.31	202.5± 3.85	11.8± 0.55	117.2± 1.67	15.4± 0.31
40	6.30± 0.03	3.5± 0.31	226.3± 5.73	11.2± 0.25	122.1± 2.14	14.5± 0.31
41	5.95± 0.03	2.8± 0.15	223.1± 3.46	10.8± 0.45	121.3± 2.04	13.5± 0.36
42	5.89± 0.03	2.9± 0.20	220.8± 4.61	12.5± 0.40	117.2± 4.22	13.3± 0.21
43	5.84± 0.08	2.7± 0.10	231.9± 3.60	13.4± 0.30	119.9± 3.85	11.4± 0.20
44	6.40± 0.05	2.6± 0.36	236.0± 3.82	15.2± 0.35	127.7± 2.20	15.1± 0.30
45	6.27± 0.02	3.7± 0.21	189.4± 3.57	14.3± 0.50	128.0± 2.55	13.8± 0.40
46	6.12± 0.03	4.5± 0.23	221.8± 4.18	12.5± 0.26	120.9± 1.36	12.6± 0.28
47	6.16± 0.05	4.5± 0.35	220.2± 5.13	11.2± 0.35	126.8± 2.55	11.0± 0.60
48	6.38± 0.04	3.7± 0.20	228.9± 2.16	12.2± 0.53	112.2± 3.76	12.4± 0.35
Range	5.48- 6.51	2.6- 5.5	183.7- 242.7	10.4- 15.2	108.1- 120.9	9.0- 15.4
Mean	6.10	3.8	218.2	12.6	120.6	12.2
SD	0.28	0.8	17.8	1.6	5.8	1.7

Table3. Soil properties and available nutrient status (N, P, K & S) in Lowland soils

Sample	pH	SOC	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	S (mg kg^{-1})
49	6.60± 0.09	4.1± 0.20	218.7± 1.75	14.6± 0.15	145.7± 3.20	11.5± 0.31
50	6.57± 0.05	4.4± 0.20	223.9± 3.01	16.8± 0.40	154.9± 2.33	14.3± 0.74
51	6.93± 0.05	3.5± 0.30	281.2± 3.14	17.5± 0.35	165.1± 3.27	16.1± 0.25
52	7.06± 0.06	3.6± 0.35	293.1± 4.01	18.5± 0.36	195.9± 3.14	17.5± 0.10
53	7.45± 0.04	3.9± 0.25	248.6± 3.85	20.3± 0.40	154.4± 1.86	16.3± 0.21
54	7.27± 0.05	3.8± 0.31	279.6± 2.59	21.4± 0.47	175.1± 3.04	14.5± 0.25
55	7.04± 0.06	5.4± 0.20	294.2± 4.46	19.5± 0.31	165.5± 3.20	18.5± 0.26
56	6.51± 0.05	5.5± 0.40	268.9± 3.32	17.4± 0.26	175.2± 2.71	16.5± 0.23
57	6.84± 0.05	3.6± 0.26	229.6± 6.12	16.6± 0.26	165.5± 3.84	14.6± 0.30
58	6.52± 0.06	4.6± 0.44	261.6± 5.93	17.6± 0.29	195.3± 2.85	13.0± 0.21
59	6.83± 0.06	5.8± 0.40	271.7± 6.56	15.4± 0.32	155.8± 3.19	13.6± 0.35
60	6.67± 0.04	5.4± 0.26	261.3± 3.67	15.6± 0.32	185.5± 3.15	15.4± 0.25
61	7.04± 0.07	4.2± 0.36	277.1± 4.22	16.5± 0.40	145.3± 2.65	18.5± 0.17
62	6.45± 0.07	4.5± 0.30	236.5±5.04	19.7± 0.50	165.6± 3.15	19.6± 0.20
63	6.79± 0.05	4.2± 0.20	269.2± 3.49	18.5± 0.36	183.3± 4.97	18.6± 0.21
64	6.60± 0.05	3.7± 0.12	283.9± 5.04	19.4± 0.25	175.5± 3.26	16.4± 0.31
65	6.91± 0.05	4.9± 0.35	286.3± 6.52	18.6± 0.23	183.2± 2.40	14.6± 0.35
66	6.58± 0.04	5.3± 0.17	230.0± 2.19	17.7± 0.57	182.3± 3.00	19.4± 0.30
67	7.06± 0.06	5.5± 0.25	236.4± 4.53	16.5± 0.30	190.2± 1.75	18.6± 0.15
68	7.11± 0.05	6.3± 0.21	241.6± 3.52	14.5± 0.30	192.1± 2.14	17.5± 0.30
69	6.81± 0.03	4.5± 0.29	254.2± 4.08	17.5±0.25	173.2± 2.55	16.5± 0.38
70	7.28± 0.03	4.3± 0.26	267.9± 5.15	18.5± 0.36	196.7± 2.05	15.8± 0.35
71	6.85±0.03	3.6± 0.42	281.9± 4.03	16.7± 0.25	184.3± 4.99	16.6± 0.42
72	6.90± 0.08	4.4± 0.21	291.4± 5.61	18.4± 0.25	184.4± 2.61	17.4± 0.20
73	7.10± 0.05	5.3± 0.21	249.0± 1.31	16.7± 0.25	169.1± 0.64	18.6± 0.20
74	6.82± 0.05	5.5± 0.36	281.2± 3.00	19.5± 0.23	175.5± 2.95	17.6± 0.25
Range	6.45- 7.45	3.5- 6.3	218.7- 294.2	14.5- 21.4	145.3- 196.7	11.5- 19.6
Mean	6.87	4.6	265.8	17.7	174.4	16.5
SD	0.26	0.8	27.6	1.7	15.0	2.1

Table4. Correlation matrix between SOC content, pH and available nutrient content (N, P, K & S) in soils

	pH	**SOC**	**N**	**P**	**K**	**S**
pH	1					
SOC	0.522**	1				
N	0.624**	0.550**	1			
P	0.726**	0.618**	0.781**	1		
K	0.719**	0.669**	0.785**	0.891**	1	
S	0.696**	0.598**	0.755**	0.858**	0.856**	1

**. Correlation is significant at the p= 0.01 level (2-tailed).

Available Potassium

Data in Table 1 to 3 show that the available potassium (K) content (kg ha^{-1}) in upland soils ranged from 84.2 to 114.7 with mean value 99.6, in medium land 108.1 to 120.9 with mean value 120.6 and in lowland soils 145.3 to 196.7 with mean value 174.4. From this study it was clear that medium and lowland soils were in medium range of available K content whereas upland soils had low content of available K. Such magnitude of available K content in rice soils under the Western central table land agro-climatic zones of Odisha was reported by Padhan et al. (2015). In lowland rice soils, the prevailing reduced environment resulted high amount of soluble Fe^{2+} and Mn^{2+} which displaced the K^{+} ions from the exchange sites resulting increased availability of potassium in the soil solution. Satpathy et al. (2015) reported that the high clay content could be the reason for high content of available K in lowland soils.

Available Sulphur

The available sulphur (S) content (mg kg^{-1}) ranged from 7.8 to 10.5, 9.0 to 15.4 and 11.5 to 19.6 with mean values of 9.4, 12.2 and 16.5 in upland, medium land and lowland rice soils respectively (Tables 1-3). Available S content maintained significant positive correlation with SOC content (0.598**) and available N content (0.755**) in soils (Table.4). Such type of relationships reported from a number of studies (Singh and Mishra, 2012; Anetta and Joanna, 2014). Poor organic matter level and coarse texture soils of upland were the result for its S deficiency (Singh and Kumar 2012). Considering the critical limit of available S content in soils to be 10mg kg^{-1}, majority of the soils of upland were deficient while soils of medium land and lowland areas were in medium range of available S content. Comparatively high content of available S in lowland soils could be due to the higher SOC content (Mohanty et al. 2012). On the contrary, reports were also there that the S availability decreased in lowland rice soils because of the reduction of sulphate under the reduced environment.

Relationship between SOC, pH and Available Nutrients

The results in Table 4 show that SOC content and pH maintained significant agreements with available nutrient contents (N, P, K and S) of soils. The result indicated that available N increased with rise in pH. Similar results were reported by Kanthalia and Bhatt (1991) and Singh and Kumar (2012). Most of the soil nitrogen as estimated based on the organic matter present in the soil. There was a definite relation of organic C with available N because organic matter releases the mineralizable N in a proportionate amount present in the soil. Hence, organic carbon status of the soil can predict the available N which shows positive relationship (0.550**) among them. Similarly organic C also markedly influenced the soil available N and the results were in agreement with Kanthalia and Bhatt (1991), Meena et al. (2006), Sharma et al. (2008), and Kumar et al. (2009). A significant and positive correlation was found between available K and soil pH (0.719**). Similar results were obtained by Sharma et al. (2008) and Singh and Kumar (2012). Available P also maintained significant positive correlations with SOC content, soil pH and other available nutrients (N, K and S) in soils. Available S showed positive correlations with soil pH (0.696**). Similar relationships were reported by Patra et al. (2012). There were outstanding agreements between available S and SOC and available N which was in line with the reports of Singh and Mishra (2012).

CONCLUSION

It can be concluded that the soils were slightly acidic to moderately acidic in reaction. The upland soils were low in fertility status. The available N content was low in all the soils. However, the available nutrients like P, K and S were low to medium range in soils of medium land and lowland areas. This information is of vital importance and acts as a major tool for scheduling balanced recommendation of fertilizer and manures to various crops. It was also concluded that the soils need prior attention regarding integrated management of nutrients and regular monitoring of nutrient status of soils for better crop productivity and sustainability.

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