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Georeferenced distribution of micro-secondary nutrients in soils of north central plateau zone of Odisha and identification of soil related production constraints in paddy

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ABSTRACT

GPS based soil samples from five pedons representing different physiography and 650 surface soil samples were collected from 26 blocks of Mayurbhanj under North Central Plateau Zone of Odisha. They were analysed and statistically interrelated following standard procedure to find out the soil nutrient based limiting factors for rice production. The study of vertical distribution of nutrients and soil parameters in pedons revealed that, the pH was acidic and increased down the depth, but, organic carbon content showed the reverse trend and status was medium to low. There were light texture surface soils with clay enriched subsurface layers. The available sulphur status of surface soils was low to marginal (7.5- 15.0 mg/kg) but, below layers were low to very low in status which was due to presence of more organics on the surface. The available Ca^{2+} and Mg^{2+} status was found to be sufficient and increase downwards like clay. The DTPA- Zn, Fe, Cu,and Mn status were marginal to adequate in surface and decreased in sub surface layers . But DTPA- Fe status was adequate in pedons.The surface soil samples were mostly acidic (96%)rest samples were neutral to slightly alkaline. The favourable EC (0.1 dS/m) indicated presence of no toxic salt level in soil. Similarly available boron status of soils was marginal to low in 61.23% samples with exceptionally few samples showing adequate values. DTPA- Zn status of 35.53% soils was low to marginal, but DTPA extractable Fe, Mn, and Cu were marginal to adequate in most of the surface soils. Soil acidity, low Organic carbon, CEC and low available S, B, Zn, light texture, were found to be some of the rice yield limiting soil factors of Mayurbhanj district. Adequate supply of deficient plant nutrients like S, B, and Zn and application of organic manure will be beneficial for increasing rice production and productivity of this agroclimatic zone.

Key words: *Pedon, surface, subsurface ,micro-secondary nutrients, distribution*

Rice is the major staple food of the people of north central plateau zone and it occupies 70 % of cultivated area. Impact of micronutrient deficiency in rice is most commonly associated given with loss of yield and low micronutrient levels in seed (Shukla *et al.* 2012). Low micronutrient levels in consumed foods contributes to malnutrition in human and animals (Mehta 1974 and Shukla *et al*. 2012). Inventory of the available nutrient status of the soils help in demarcating areas where, the application of a particular nutrient is needed for profitable rice production (Sood *et al.* 2009). Micro and secondary nutrients play a vital role for increasing rice productivity and enhancing the quality of produce. In the era of first green revolution much emphasis given on use of primary nutrients through chemical fertilizers devoid of micro and secondary nutrients resulted in

depletion of these nutrients from soil. Further, cultivation of HYV led to mining of more nutrients. Gradual reduction of application of organic manures is another cause of depletion of micro and secondary nutrients from soil. Some of them like iron is present in toxic level causing nutrient imbalance and reduction in rice yield. Blanket application of these nutrients without soil testing very often created an environment for poor nutrient use in soil. As a consequence there was reduction in yield as well as factor of productivity. It is revealed from various research results that, application of micro and secondary nutrients to crops are encouraging (Shukla *et al.* 2012). So information on soil status related to micro and secondary nutrients of an area is required for proper planning for rice cultivation. Soil testing reveals the problem and prospect of a soil for sustainable crop production and management . Based on the soil test results of different AICRP's, Shukla *et al.* (2012) reported that secondary and micronutrient deficiencies are rampant in the country. Particularly Zinc and Boron in acid soils caused yield reduction and degradation of grain quality of crops. Hence, under the present study efforts have been made to characterize the georeferenced rice growing soils of Mayurbhanj district of north central plateau zone of Odisha with respect to secondary and micronutrient status of surface and subsurface soils.

MATERIALS AND METHODS

Study site

Mayurbhanj is a tribal dominated agriculturally important district situated in the north central plateau zone of Odisha and is surrounded by Medinipur district of West Bengal, Singhbhum district of Jharkhand in north west, Balasore district in the south east and by Keonjhar district of Odisha in southwest (Fig.1) The district has a geographical area of 10418 sq kms with 26 blocks (Fig.1). The district experiences a sub tropical climate ,receives average rainfall of 1648 mm, mean maximum temp 36.6^{0}C and mean minimum temp of 11.1^{0}C. The district is mostly dominated by red and laterite soil. Paddy is the major crop grown in the district followed by arhar and maize. Production and productivity of many crops including paddy in the district are less due to imbalanced fertilizer use, non inclusion of secondary and, micronutrients, less use of organics *etc*.

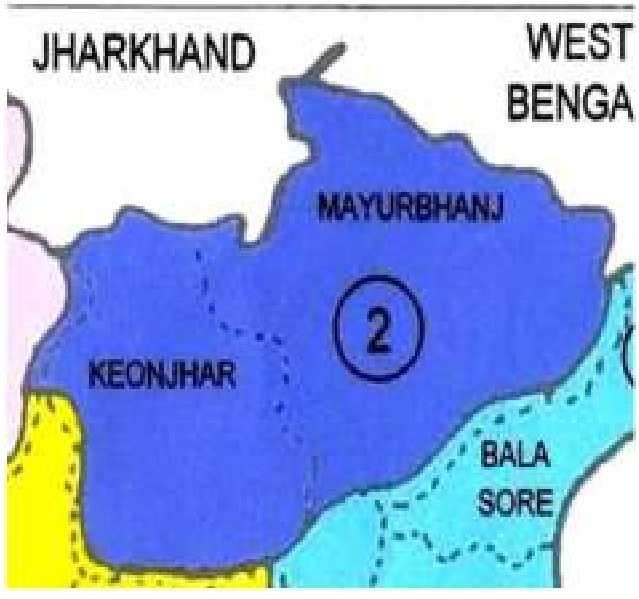

Fig.1. North Central Plateau Agroclimatic Zone (Mayurbhanj district) of Odisha

Soil analysis

To have knowledge regarding soil fertility status with respect to secondary and micronutrients 650 georeferenced surface soil samples were collected from 26 blocks of the district. Five pedons representing high, medium and low land were exposed and soil samples were collected to know subsurface micro and secondary nutrient distribution under this zone.

The soil samples collected were air dried, processed, and analysed for various physico-chemical properties following standard procedure. The pH (1:2.5) and electrical conductivity of soils were measured as described by Jackson (1973). Soil OC content was estimated by Walkley & Black (1934) rapid titration method and, exchangeable Ca by EDTA titration method (Page *et al.* 1982).

Available Sulphur (0.15% $CaCl_2$ extracted) content was determined spectrophotometrically using $BaCl_2$ (Chesnin L and Yien CH 1951).The soils were extracted with 0.005 M DTPA (pH 7.3) solution for estimation of Fe, Mn, Zn and Cu by Atomic absorption Spectrophotometer (AAS) as per Lindsey and Norvell (1978). Available Boron extracted by Hot water (Berger and Trough 1939) was determined colorimetrically using Azomethin H indicator (John *et al.* 1975).

Table 1. Some basic properties and Secondary nutrient (mg/kg) content of soils of different Blocks of Mayurbhanj

Name of block	pH (1:2.5)	EC (dS/m)	OC (g/kg)	Available S (mg/kg)		Exchangeable Mg^{2+} (cmol (p+/kg)		Exchangeable Ca^{2+}(cmol (p+/kg)	
	Aver.	Aver.	Aver.	Range	Mean	Range	Mean	Range	Mean
Muruda	4.93	0.08	1.07	0.38-30.44	14.15	0.4-10.2	3.88	0.5-2	1.24
Rasagovindpur	5.21	0.09	1.54	2.28-99.69	28.38	0.6-3.4	2.05	0.7-8.1	2.58
Bangiriposi	5.36	0.08	1.23	5.71-74.20	23.41	0.4-4.6	2.57	0.9-4.3	2.7
Kuliana	5.53	0.17	0.82	3.04-120.24	17.67	0.4-4.5	2.44	0.5-8.4	3.24
Suliapada	4.94	0.08	0.80	0.38-37.67	10.15	0.3-2.7	1.22	0.9-8.6	3.27
Samaskhunta	5.37	0.05	1.17	0.38-85.61	23.76	0.3-5.8	1.88	0.6-14.1	3.35
Baripada	5.09	0.07	0.81	0.38-7.61	2.86	0.3-1.7	0.74	1.1-2.6	1.67
Saraskana	5.68	0.11	0.71	0.38-33.86	6.65	0.4-5.6	2.48	0.5-3.1	1.87
Thakurmunda	4.58	0.06	0.76	6.91-55.55	34.71	0.3-5.9	1.81	0.4-3.6	2.11
Karanjia	5.08	0.06	1.36	15.22-51.37	32.07	0.4-3.1	1.44	0.8-5.9	2.87
Jashipur	4.89	0.10	1.50	1.14-50.23	16.04	0.3-4	2.1	1.2-5.5	2.88
Raruan	4.93	0.05	0.92	0.38-38.81	7.93	0.5-2.6	1.53	0.9-4.5	2.35
Sikruli	4.63	0.06	1.06	1.91-30.06	9.92	0.2-2.6	1.54	1.2-6.7	3.27
Kaptipada	5.16	0.11	1.25	1.52-105.02	16.98	0.6-3.9	1.71	1.1-6.8	3.74
Gopabandhunagar	4.67	0.10	0.97	3.04-58.98	14.67	0.8-2.5	1.46	1.9-2.9	2.47
Udala	4.82	0.10	1.51	3.81-133.56	28.75	0.2-1.6	1.09	0.9-6.3	2.67
Khunta	4.59	0.06	1.54	3.42-56.31	17.21	1.3-7.1	3.23	0.7-5	2.71
Badasahi	4.47	0.11	1.56	0.38-35.76	11.31	0.4-4.4	1.44	0.7-3.5	2.05
Betnati	4.50	0.07	0.96	0.76-43.37	20.97	0.3-3.1	1.24	0.4-12.1	3.32
Bisoi	4.81	0.08	1.20	0.76-48.33	20.15	0.2-2.4	1.43	1.8-6.6	2.87
Bijatola	4.82	0.13	1.31	0.76-110.81	25.54	0.5-5.3	2.49	1.4-7.6	3.51
Rairangpur	4.52	0.09	1.22	4.94-72.68	31.58	0.3-3.3	1.78	0.6-3.5	1.71
Bahalda	4.73	0.08	1.12	1.52-49.47	22.07	0.3-3.5	1.51	0.6-3.2	1.65
Tiring	5.30	0.12	0.97	4.95-99.31	40.50	0.8-6	2.9	1-11.5	4.77
Jamda	4.58	0.07	0.51	3.04-72.68	43.35	0.3-8.7	2.51	0.4-3.1	1.77
Kusumi	5.20	0.09	0.56	14.07-125.57	43.76	1.2-4.5	2.6	2-7.2	3.63
Overall	4.47-5.68	0.05-0.17	0.51-1.56	0.38-133.60	21.71	0.20-10.20	1.96	0.4 -14.1	2.70

Statistical analysis

Data were subjected to statistical analysis. The minimum, maximum, mean, standard deviation (SD), coefficient of variation (CV) for soil parameters were computed .

RESULTS AND DISCUSSION

From analysis of samples for various physico-chemical properties it was found that 96% of surface soils samples were acidic (pH < 6.5) in reaction and rest 4% neutral. Electrical conductivity was normal (0.054-0.167 dS/m) for most of the samples.Organic carbon was medium (0.51 to 1.56g/kg).

Available secondary nutrient of surface soils

The data on available secondary nutrients content of surface soils are presented in Table 1. The mean exchangeable Ca and Mg content of soils were 2.70 and 1.96 cmol (P^+)/kg and the values ranged from 0.4to 14.1 and 0.2 to 10.2 cmol (P^+)/kg respectively. The $CaCl_2$ extractable sulphur ranged between 0.38 and 133.60 mg/kg with mean value of 21.71 mg/kg for the district. Most of the secondary nutrients were found to be sufficient. The extent of deficiency of sulphur was 34.46% in the district. The percent sample deficient for sulphur ranged between 0-100 in different blocks (Table 4). The maximum deficiency was found in Baripada block while that of minimum in Karanjia block. It's deficiency may be attributed to low SOC less or no application of S containing fertilizer , intensive cropping and low S in parent material.

Available Micronutrient status of surface soils

Available micronutrient status of surface soil are presented in Table 2. The DTPA-Fe of soils of different blocks ranged from 0.14- 410.88 mg/kg, the maximum and minimum values observed in Kaptipada and Baripada block, respectively. The mean DTPA extractable Fe content of different blocks of the district varied from 10.93-212.56 mg/kg. The above values for all blocks were found to be sufficient. Such high Fe

Table 2. DTPA extractable Fe, Cu and Mn content (mg/kg) of Surface soils of Mayurbhanj

Sl. No.	Block	Fe		Cu		Mn
		Range	Mean	Range	Mean	Range
1	Muruda	27.18-215.84	95.61	0.80-5.56	3.01	7.98-164.46
2	Rasagovindpur	16.46-312.06	132.55	0.73-81.88	6.95	13.24-213.9
3	Bangiriposi	31.78-270.48	119.64	1.26-8.49	4.89	8.78-206.36
4	Kuliana	32.6-246.54	133.07	2.02-76.48	9.09	12.16-132.32
5	Suliapada	32.86-353.52	147.65	0.092-7.43	2.39	6.44-188.48
6	Samaskhunta	12.74-242.88	62.91	1.45-14.58	5.51	8.02-96.26
7	Baripada	0.14-50.24	10.93	0.18-3.31	0.77	4.88-144.24
8	Saraskona	0.32-108.1	13.400	0.33-2.64	1.415	13.64-101.46
9	Thakurmunda	4.180-173.96	72.66	0.59-4.93	2.38	0.92-84.84
10	Karanjia	2.3.40-53.66	127.36	1.01-3.83	2.43	0.84-117.20
11	Jashipur	48.98-353.04	160.88	1.61-7.67	4.13	10.68-116.8
12	Raruan	70.76-312.24	166.82	1.29-1.78	4.38	13.88-162.60
13	Sikruli	50.36-374.4	182.27	3.22-6.91	5.02	18.28-192.30
14	Kaptipada	8.88-410.88	139.22	0.84-7.13	3.40	12.16-382.72
15	Gopabandhunagar	47.8-217.28	150.08	1.29-8.05	4.59	2.76-118.02
16	Udala	21.16-376.8	141.95	0.08-10.28	3.69	11.08-200.64
17	Khunta	11.30-193.88	106.28	0.35-8.85	3.90	1.02-157.80
18	Badasahi	67.08-405.44	148.92	0.88-6.19	3.23	9.56-305.04
19	Betnati	2.16-256.56	130.59	0.41-10.62	2.82	0.44-80.12
20	Bisoi	53.28-289.44	139.66	1.19-5.57	3.273	13.96-195.6
21	Bijatola	34.24-242.64	111.63	1.11-8.83	3.5	12.20-173.04
22	Rairangpur	104.68-315.12	212.56	3.13-6.43	4.57	17.82-210.36
23	Bahalda	48.24-253.74	136.09	1.45-7.67	3.49	8.58-177.36
24	Tiring	20.6-268.14	135.02	0.47-8.72	3.48	10.32-218.92
25	Jamda	12.44-320.04	97.198	0.76-5.75	3.29	5.72-356.00
26	Kusumi	10.04-213.68	127.14	0.18-6.48	3.01	9.24-214.4
	OVERALL	0.14-410.9	123.15	0.08-81.9	3.79	0.44-382.7

content may be due to presence of iron rich parent materials like laterites. This might cause iron toxicity in rice under medium and low land situation.

The DTPA extractable- Mn content of surface soils varied from 0.44 to 382.72 mg/kg maximum value was observed in Kaptipada and minimum in Betnati block of Mayurbhanj district. The mean value of Mn ranged between 18.062 and 107.93mg/kg. Mean minimum value was in Muruda block and maximum was in Kaptipada block. Overall status of Mn was sufficient in most of the blocks except in 1.6 % of samples where the value were below the critical limit.

The DTPA-Cu status of surface soils ranged from 0.08 to 81.88 mg/kg, the highest value being observed in Rasgovindpur block and in Udala block Table 2. The mean available Cu value varied from 0.77 to 9.09 mg/kg. The status of available Cu in most of the soils was above critical limit (0.4 mg/kg). The data on available Zn and B content of soils are presented in Table 3.

The DTPA-Zn content of soils ranged from 0.01 to 15.16 mg/kg, the minimum in Rasgovindpur and the maximum in Udala block of the district. The mean available Zn content varied from 0.59 to 3.75 mg/kg. The zinc status of soil in the district was found to be deficient up to 35.53 % in surface samples which may be due to insufficient Zn in parent material, and deemphasis of zinc application to crop.

The hot water soluble B content of surface soils of Mayurbhanj district varied from 0.01 to 5.80 mg/kg (Table 3). The data revealed that 61.23 % of soils were deficient in boron out of which 44.61% had less than 0.3 mg/kg and rest 16.62 % contained available B in the range of 0.3 to 0.5 mg/kg. Boron is a key element for transportation of photosynthates, pollen tube elongation and important in metabolic process. The status of B deficiency in surface soil of Mayurbhanj district was alarming it might be due to light texture acidic pH of soil leading to excess leaching of B. The soil might have developed from a parent material poor in B.

Table 3. Available Zinc and Boron content (mg/kg) of surface soils of Mayurbhanj

Block	DTPA-Zn		HWS-B	
	Range	Mean	Range	Mean
Muruda	0.44-2.48	1.25	0.13-3.34	0.87
Rasagovindpur	0.01-7.72	3.75	0.44-3.86	1.98
Bangiriposi	0.14-1.89	0.96	0.02-3.77	0.57
Kuliana	0.12-1.71	0.76	0.07-1.05	0.54
Suliapada	0.09-2.02	0.79	0.15-1.71	0.78
Samaskhunta	0.08-2.92	0.98	0.05-1.41	0.66
Baripada	0.02-0.74	0.32	0.04-3.88	1.66
Saraskona	0.03-1.78	0.65	0.07-3.62	1.83
Thakurmunda	0.21-0.76	0.598	0.05-1.41	0.53
Karanjia	0.31-1.67	0.90	0.03-2.06	0.54
Jashipur	0.17-2.41	0.94	0.028-2.16	0.48
Raruan	0.31-1.66	0.84	0.02-1.02	0.25
Sikruli	0.41-2.72	1.05	0.03-1.33	0.94
Kaptipada	0.21-1.12	0.64	0.25-1.27	0.54
Gopabandhunagar	0.09-2.54	1.02	0.03-0.73	0.26
Udala	0.03-15.16	1.42	0.04-1.96	0.39
Khunta	0.07-1.36	0.71	0.02-1.34	0.49
Badasahi	0.28-2.58	0.99	0.03-5.80	0.61
Betnati	0.19-2.39	0.84	0.02-0.63	0.21
Bisoi	0.35-3.12	1.14	0.01-.039	0.13
Bijatola	2.95-0.23	0.820	0.03-1.76	0.38
Rairangpur	0.70-2.47	1.38	0.02-1.65	0.25
Bahalda	0.17-1.27	0.675	0.03-.034	0.13
Tiring	0.18-1.85	0.644	0.01-0.55	0.18
Jamda	0.21-2.76	0.779	0.01-1.96	0.25
Kusumi	0.19-2.67	1.010	0.1-0.68	0.13
Overall	0.01-15.16	0.99	0.01-5.80	0.60

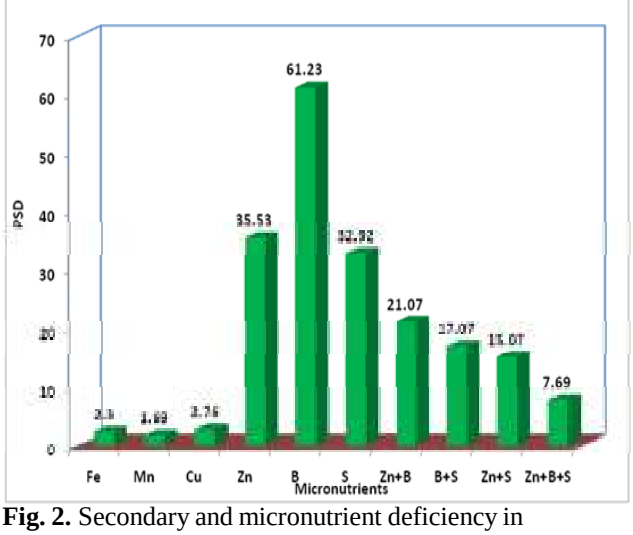

Fig. 2. Secondary and micronutrient deficiency in Mayurbhanj district

Multinutrient deficiency in surface soils:

More than one nutrient deficiency at one site is more harmful than that of single nutrient. Strategy for management of alleviating multi nutrient shortage in a crop grown at that site is to be taken care of. Deficiency of Zn & B, B & S, Zn & S and Zn & B & S were found up to 21.07, 17.07, 15.07 and 7.7 respectively in the district of Mayurbhanj (Fig. 2).

Table 4. Micro-secondary nutrient deficient soil percent in different blocks of Mayurbhanja

Block name	Samp-	PSD (%)					
	le Size	Fe	Mn	Cu	Zn	B	S
Muruda	25	0	0	0	12	52	36
Rasagovindpur	25	0	0	0	16	4	52
Bangiriposi	25	0	0	0	28	64	16
Kuliana	25	0	0	0	44	56	52
Suliapada	25	0	0	1	44	44	60
Samaskhunta	25	0	0	1	24	36	20
Baripada	25	16	0	12	92	12	100
Saraskana	25	36	0	3	56	28	80
Thakurmunda	25	4	20	0	64	52	4
Karanjia	25	0	4	0	44	0	0
Jashipur	25	0	0	0	28	68	24
Raruan	25	0	0	0	40	80	72
Sikruli	25	0	0	0	20	24	56
Kaptipada	25	0	0	0	52	48	44
Gopabandhunagar	25	0	4	0	28	88	44
Udala	25	0	0	0	28	96	36
Khunta	25	0	0	1	36	48	32
Badasahi	25	0	0	0	36	56	32
Betnati	25	4	16	0	36	88	20
Bisoi	25	0	0	0	8	100	16
Bijatola	25	0	0	0	32	76	60
Rairangpur	25	0	0	0	0	92	4
Bahalda	25	0	0	0	44	100	20
Tiring	25	0	0	0	48	96	12
Jamda	25	0	0	0	36	88	4
Kusumi	25	0	0	0	28	96	0
Deficiency Range	650	4-36	16-20	1-12	0-92	0-100	0-100
Overall deficiency		2.3	1.69	2.76	35.53	61.23	34.46

Vertical distribution of secondary and micronutrients in Mayurbhanj

To know the vertical distribution or subsurface status of micro and secondary nutrients and some common soil properties, five pedons representing different locations and physiographic situations were studied.

Morphological and physical properties of pedon soils

The soil colour and particle distribution of pedons are presented in Table 5. It was observed that soil colour varied from pale yellow to red in diffeerent pedons. Fine earth fraction of soils were calculated and it was observed that, sand content varied from 50.6 to 87.6%

Table 5. Morphological and Physio-chemical properties of pedon soils

Profile	Genetic Hori-zons	Depth (cm)	Colour	pH (1:2.5)	OC (mg/kg)	Sand %	Silt %	Clay %	Ca (cmol (p^+)/kg)	Mg (cmol (p+)/kg	S (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	B (mg/kg)
1	Ap	0-20	Strong brown	5.32	6.1	86.6	2.0	11.4	3.2	1.5	9.5	0.49	55.6	0.56	20.8	0.67
Upland	Bt1	20-46	Red	5.35	4.55	76.6	8.0	15.4	4.8	2.1	3.5	0.31	61.3	0.49	16.1	0.58
Shamakunta	Bt2	46-67+	red	5.52	2.71	72.6	9.0	18.4	6.0	2.9	1.5	0.20	75.6	0.26	14.5	0.31
2	Ap	0-20	Pale yellow	5.6	6.46	87.6	3.0	9.4	5.20	2.6	47.5	0.13	59.9	0.98	29.7	1.05
Mid	Bw1	20-50	Brownish yellow	6.27	3.14	70.6	6.0	23.4	7.10	3.8	21.2	0.25	39.4	0.42	17.1	0.91
Land	Bw2	50-70	Light yellowish brown	6.22	1.95	62.6	10.0	27.4	8.90	4.8	15.0	0.5	24.2	0.32	16.6	0.71
Baripada	Bw3	70-100	Light yellowish brown	6.3	0.62	50.6	14.0	35.4	10.3	5.6	5.0	0.6	13.5	0.06	16.2	0.44
3	Ap	0-12	Olive yellow	5.14	6.1	84.6	5.0	10.4	4.1	2.4	10.0	0.57	68.54	0.97	15.7	0.52
Mid	Bw1	12-32	yellow	5.58	4.25	78.6	7.0	14.4	6.3	3.2	7.5	0.38	51.04	0.45	14.6	0.46
Baripada	Bw2	32-57	Reddish yellow	5.91	2.31	70.6	8.0	21.4	8.6	4.2	2.5	0.15	40.3	0.25	12.6	0.34
	Bw3	57-110	Yellowish red	6.1	1.12	68.6	8.0	23.4	9.2	5.6	2.0	0.14	29.8	0.17	9.1	0.31
4	Ap	0-18	Olive yellow	5.07	6.03	84.6	4.0	11.4	4.6	2.1	7.5	0.61	49.58	0.54	16.1	0.50
Mid	Bw1	18-48	Brownish yellow	5.36	4.16	78.6	6.0	15.4	3.2	2.5	3.4	0.54	23.0	0.46	15.6	0.41
land	Bw2	48-86	Brownish yellow	5.46	2.65	67.6	7.0	25.4	8.6	4.2	1.0	0.22	11.52	0.36	15.3	0.39
	Bw3	86-105	Strong brown	5.54	0.92	63.6	13.0	23.4	9.8	4.5	0.5	0.18	7.66	0.36	12.3	0.31
5	Ap	0-20	Light yellowish brown	6.64	8.96	70.6	18.0	11.4	20.6	7.4	15.0	0.45	42.8	0.85	15.6	0.41
Low	Bw1	20-40	Light brownish gray	8.15	5.27	60.6	20.0	19.4	24.0	8.4	5.0	0.52	33.42	0.72	9.5	0.24
Land	Bw2	40-70	Light yellowish brown	8.22	3.52	56.6	20.0	23.4	28.8	11.2	2.5	0.21	18.16	0.35	6.0	0.23
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the maximum value being reported in Pedon-2 followed by Pedon-5 and others. The sand content gradually decreased down wards in all pedons. The silt content ranged from 2-20% in different layers of the pedons. Maximum value of silt was found in Pedon-5 and minimum in Pedon-1. The value increased down the depth. The clay content increased downward ranging from 9.4 to 35.4 % in all pedons both maximum and minimum value of clay were observed in Pedon-2.

Status of secondary nutrients in pedon soils

Secondary nutrient content of pedon soils were analysed and presented in Table 5. The sulphur content varied from 0.5 to 47.5 mg/kg. The maximum value was found in pedon-2 and minimum in pedon-4. The available sulphur value decreased with increasing depth of pedon. The values for Ca^{2+} and Mg^{2++} varied from 3.2 to 28.8 and 1.5 to 11.2 cmol (p^+)/kg, respectively and increased towards subsurface horizons. The maximum and the minimum values of Ca and Mg were observed in the low land and upland pedons, respectively.

Vertical distribution of micronutrient in the pedon

The results of micronutrient analysis are presented in Table 5. It was revealed from the data that the DTPA-Fe varied from 7.66 to75. 6 mg/kg in different depths of the pedon. The maximum value was in pedon-1, and the minimum in pedon-2. The value of DTPA-Fe showed a decreasing trend down the depth in all pedons except in pedon-1. Mn content varied from 6.0 to 29.7mg/kg. The maximum value was observed in pedon 1 and the minimum in pedon-2. The value of available Mn soil decreased downward in all pedons.

DTPA-Zn content of soil varied from 0.13 to 0.60 mg/kg in all pedons. The values decreased downward with depth in all except pedon-1 wine reverse trends was reversed. Hot water soluble (HWS-B) of soil ranged from 0.23 to 1.05 mg/kg in the soils of different pedons. Maximum values were observed in pedon-2 where as minimum value in pedon-4. In all pedons the available B content of soils were found to decrease with increase in the depth.

Conclusion

From the above study, it was found that 96% surface soils of Mayurbhanj were acidic (pH < 6.5) in reaction

and the rest 4% were neutral and non saline .The soils showed S deficiency up to 34.46 % which need soil test based S application. Deficiency of Boron (61.23%) was observed in surface soils of Mayurbhanj. Thus B management in soils and rice crops should be taken care in the district. The surface soils were rich in Fe, Mn and Cu. The mean DTPA-Zn value for surface soils varied from 0.592 to 3.75 mg/kg where 35.53% samples were found deficient. The deficiency of secondary and micronutrients followed the order as B>Zn>S. Multinutrient deficiency were also observed to an extent of 7.7 to 21.1 % of soil samples. Sub-surface micro and secondary nutrient status studied in five pedons of soil s representing up, mid and low lands indicated that Fe, Mn, Zn & Cu were high in Surface soil that gradually decreased downward. HWS-B status was low in Surface soil of all 5 pedons which decreased downward due to leaching under high rainfall and light texture condition. By taking into consideration the current soil status, the micro and secondary nutrient management strategy for rice and other crops needs to be developed. Adequate supply of deficient plant nutrients like S, B, and Zn, amelioration of acid soils steps for reducing iron toxicity and application of organic manure will be beneficial for increasing rice production and productivity of this agroclimatic zone.

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