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Secondary and Micro Nutrient mapping in forest soils of Kandhamal district, Odisha

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Abstract: Emergence of widespread secondary and micro nutrient deficiencies have become major constraints of productivity. Farmers give hardly any emphasis on application of these nutrients. As a result decline or stagnation in production and productivity of many crops is observed creating a huge gap between the requirement and supply of food grains. For efficient soil and crop management soil test based fertilizer application is highly essential. major nutrient analysis is often done micro nutrient analysis is usually neglected due to prohibitive costs and expensive instruments. Data on soil micro and secondary nutrients status were used for generation of soil fertility maps in GIS environment. In the present paper GPS based soil survey was conducted during 2012-13 where spatially distributed georeferenced soil samples (0-20 cm depth) were collected from forest soils of Kandhamal district, Odisha and analysed for various secondary and micronutrients along with some basic parameters like pH, EC and OC. Derived thematic maps showed deficiency of sulphur to an extent of 82.5% followed by boron and Zinc as the limiting elementing of Kandhamal soils.

Keywords*: Nutrient mapping soil survey, forest soils*

Introduction

Production and productivity of many crops is declining due to decline in soil fertility status, imbalanced fertilizer use, lack of knowledge on micro and secondary fertilizers etc. Efficiency of major nutrients is increased in presence of micronutrients (Mehta 1974). There exists a narrow gap between the deficiency and toxicity level. micronutrients and recommendation without soil testing can lead to anomalies. Global Positioning System (GPS) based, soil sampling can provide a basis for developing site-specific nutrient management via soil fertility maps. In Odisha visual symptoms of deficiency / toxicity of some secondary and micronutrients on crops have been observed at various locations. Hence, a systematic study was conducted to generate information on extent of secondary and micronutrient deficiency or toxicity areas under different soil types and the matic maps have been genrated for different nutrients under GIS environment .

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Materials and Methods

Study area

Kandhamal**,** a tribal dominated district occupies a central position in the Geo-Political map of Odisha. It lies between 83° 30^{1}E to 84° 48^{1} E longitude and between 19° 34^{1} N to 20° 54^{1} N latitude in agro climatic zone of sub-region Eastern Ghats and part of Eastern Plateau. It has a total geographical area of 8021Sq Km with an average annual rainfall of 1597 mm (62.9). The average minimum and maximum temperatures are 1° in December to 35°C respectively.

Soil Sampling

Grid sampling was done at 1x1 km distance ensuring minimum 25 samples from each administrative block. The latitude, longitude and elevation at each sampling site were recorded using a hand held GPS and 595 georeferenced surface soil samples were collected from 12 blocks of the district.

Soil Analysis

Soil samples were air dried, processed, passed through 2 mm sieve for analysis of nutrients. pH and EC were measured in 1: 2.5 soil water ratio (w/v) suspension using pH meter and EC meter respectively. Soil OC content was estimated by Walkley and Black (1934) method, Exchangeable Ca by EDTA titration method (Page *et al.* 1982). Available sulphur was determined spectrophotometrically as described by (Chesnin and Yien (1951). The micronutrient (Mn, Fe, Zn, Cu) from soils were extracted with 0.005 Diethylene Triamine Penta Acetic acid (DTPA) as per method out lined by Lindsey and Norvell (1978). Hot water soluble boron was estimated as per the method outlined by Berger and Trough (1939). Data were subjected to descriptive analysis.

Results and Discussion

Data on basic parameters like pH, EC, OC are presented in Table 1. The pH ranged from 4.06 to 8.560 Electrical conductivity of these soils ranged from 0.004 to 0.959 dS m^{-1}. Organic carbon content of soils ranged from 0.02 to 3.9%.

Available $SO_4^{-}{}_5^{-}$ varied from 0.38-202.96 mg kg^{-1} with a mean value of 8.77 mg kg^{-1} (Table 2) and was deficient in 82.5 percent sample.

In general soils are sufficient in Fe, Mn and Cu. Nearly 3.2% soils showed Cu deficiency in Khajuripada (2%) and Raikia (20%). The Fe content in soils ranged from 0.012-405.2 mg kg^{-1} with mean value of 81.98 mg kg^{-1}. The DTPA- Cu content ranged from 0.04 to 4.16 mg kg^{-1} with mean value of 1.048 mg kg^{-1}. The Mn content ranged from 1.2 to 400.56 mg kg^{-1}. DTPA Zn content in soils ranged from 0.017 to 32.77 mg kg^{-1} with mean value of 1.099 mg kg^{-1}. Zn deficiency was observed in all blocks of the district. (33.45%). Hot water soluble boron status of soils ranged from 0.03 to 3.56 mg kg^{-1}, with mean value of 0.38 mg kg^{-1}, with deficiency of 79.66% percent soil samples.

It may be summarized that soils of the district are sufficient in Fe, Mn, Cu but deficient in S, B and Zn. The deficiency was in the order of S (82.5%) > B(79.7%) > Zn (33.45%) > Cu(3.2%) > Fe (0.36%). High deficiency of S and B in Kandhamal soils might be attributed to high altitude upland (Alfisols) leading to leaching of anionic nutrients.

Based on the above results digitized soil fertility map for sulphur, boron, zinc, copper, manganese and iron were prepared (Fig. 1 through 6).

Table 1. pH, EC and OC in soils of Kandhamal district

Block nam e	**No. of samples**	**pH (1:2.5)**	**EC (dS m^{-1})**	**OC (%)**
Khajuripada	50	4.92-7.06	0.012-0.44	0.18-2.81
			(0.07)	(0.76)
Phulbani	75	4.53-7.5	0.013-0.233	0.1-2.71
		(5.79)	(0.06)	(0.71)
Phiringia	74	4.88-7.92	0.011-0.795	0.08-1.66
		(5.83)	(0.09)	(0.64)
Raikia	40	4.86-7.29	0.018-0.44	0.039-1.90
		(5.75)	(0.08)	(0.62)
Tikabali	21	4.71-7.43	0.028-0.476	0.16-3.90
		(5.91)	(0.09)	(0.72)
G. Udayagiri	38	4.78-6.86	0.016-0.18	0.23-1.69
		(5.88)	(0.05)	(0.84)
Nuagaon	31	4.5-7.02	0.024-0.6	0.31-1.59
		(5.83)	(0.10)	(0.63)
Baliguda	24	4.4-7.3	0.025-0.57	0.21-1.16
		(5.53)	(0.12)	(0.61)
Chakapada	32	4.72-6.79	0.015-0.303	0.18-1.21
		(5.83)	(0.085)	(0.560)
Tumudibandha	25	4.89-6.06	0.038-0.115	0.06-1.42
		(5.55)	(0.06)	(0.61)
Daringibadi	140	4.06-7.42	0.004-0.948	0.06-1.79
		(5.69)	(0.09)	(0.75)
Kotagarh	45	5.05-8.56	0.015-0.959	0.02-0.99
		(5.99)	(0.14)	(0.50)
Total	**595**	**4.06-8.56**	**0.004-0.959**	**0.02-3.9**
		(5.78)	**(0.08)**	**(0.68)**

Number within parenthesis denote mean values.

Table : 2. Micro and secondary nutrient in soils of Kandhamal.

Block name	No. of samples		Fe	Mn	Cu	Zn	B	S
			mg kg^{-1}					
Khajuripada	50	Range	31.38-226.52	5.81-112.56	0.138-1.834	0.017-22.1	0.080-1.89	0.76-16.32
		Mean	95.86	52.21	0.90	1.656	0.916	3.658
		*PSD	-	-	**0.12**	**18.0**	**10.0**	**96.0**
Phulbani	75	Range	14.2-405.2	1.2-309.0	0.106-2.048	0.19-4.76	0.039-2.33	0.38-36.72
		Mean	136.41	65.91	0.874	0.966	0.370	6.14
		*PSD	-	4.00	8.00	**23.61**	**77.7**	**94.4**
Phiringia	73	Range	13.44-254.8	16.48-290.75	0.216-2.59	0.325-32.773	0.030-1.66	0.38-91.09
		Mean	97.06	100.41	1.05	1.64	0.457	5.21
		*PSD	-	-	2.7	**16**	**16**	**92**
Raikia	70	Range	8.32-179.1	23.55-228.3	0.043-2.111	0.092-3.218	0.040-3.56	0.71-196.54
		Mean	63.86	89.98	0.72	0.87	0.312	24.54
		*PSD	-	-	12.8	-	-	-
Tikabali	21	Range	27.4-209.68	7.52-105.04	0.1798-2.164	0.276-4.02	0.039-0.43	1.13-82.40
		Mean	95.32	48.74	0.78	1.03	0.256	8.33
		*PSD	-	-	19.0	**28.57**	**100**	**90.48**
G.Udayagiri	38	Range	13.2-217.6	6.9-311.15	0.054-3.049	0.158-3.698	0.040-0.927	0.38-54.44
		Mean	70.71	88.85	1.01	1.24	0.267	5.46
		*PSD	-	-	18.4	**21**	**92.10**	**86.84**
Nuagaon	31	Range	32.4-159.9	19.0-154.65	0.043-1.59	0.092-2.20	0.04-3.56	1.07-196.54
		Mean	62.00	93.06	0.66	0.77	0.399	35.49
		*PSD	-	-	25.8	**41.9**	**77.42**	**32.26**

Contd....

		Range	0.012-213.75	11.57-141.28	0.437-2.654	0.344-4.988	0.230-1.03	0.76-37.42
Baliguda	17	Mean	79.93	70.35	1.28	1.55	0.428	4.76
		*PSD	-	-	-	**21.74**	**78.3**	**95.65**
		Range	25.4-228.35	9.08-145.1	0.288-2.736	0.39-6.48	0.040-2.250	0.38-202.96
Chakapada	32	Mean	106.08	70.935	0.994	0.966	0.244	9.44
		*PSD	-	-	6.2	**29.0**	**93.8**	**84.4**
		Range	8.54-179.22	51.56-126.22	0.54-2.852	0.098-6.14	0.125-0.333	0.71-36.29
Tumudibandha	25	Mean	43.254	80.834	1.255	0.887	0.201	6.66
		*PSD	-	-	-	**60**	**100**	**80**
Daringibadi	140	Range	0.95-304.0	7.12-324.6	0.042-4.159	0.078-7.53	0.039-2.435	0.71-40.25
		Mean	59.05	115.74	1.39	0.77	0.291	7.72
		PSD	1.43	-	10.7	**54.28**	**92.14**	**81.43**
Kotgarh	45	Range	1.36-156.64	6.44-400.56	0.132-1.642	0.021-8.48	0.039-2.428	1.42-51.24
		Mean	59.69	59.69	0.898	1.076	0.436	8.82
		PSD	-	-	4.40	**40.0**	**80**	**75.55**
		Range	**0.012-405.2**	**1.2-400.56**	**0.042-4.159**	**0.017-32.773**	0.030-3.56	0.38-202.96
Total	**595**	**Mean**	**81.98**	**85.61**	**1.05**	**1.099**	**0.38**	**8.77**
		***PSD**	**0.36**	**0.33**	**10.9**	**34.62**	**79.15**	**82.52**

* Per cent sample deficient

Out of 595 samples 159 samples were analyzed for exchangeable Ca^{+2}, the range and mean are presented in table 3. It was found that exchangeable Ca^{+2} content varied from 0.75-15.4 cmol (p^{+}) kg^{-1} with mean value of 4.62 cmol(P^{+}) kg^{-1} and it was above critical limit.

Table 3. Block wise Exchangeable Ca content of Kandhamal soils

	Block	Sample	Range [cmol(P^{+}) kg^{-1}]	Mean
1	Khajuripada	28	1.2-12.4	5.52
2	Phulbani	9	1.13-5.38	2.75
3	Phiringia	21	4.2-12.2	9.01
4	Raikia	8	3.6-7.4	5.25
5	Tikabali	10	3.8-8.6	5.86
6	G.Udayagiri	12	2.6-6.6	3.73
7	Nuagaon	10	0.75-2.63	1.44
8	Baliguda	9	3.8-6.2	5.07
9	Chakapada	11	4.40-15.40	7.33
10	Tumudibandha	8	1.20-4.40	2.30
11	Daringibadi	24	1.0-8.0	4.31
12	Kotgarh	9	0.75-6.25	2.89
		159	**0.75-15.4**	**4.62**

Multinutrient deficiency was observed at many grid points. Table 4 shows that boron and sulphur deficiency occurred together in almost 40% samples, while 23% samples showed common deficiency of zinc, boron and sulphur together.

Table 4. Extent of Multimicronutrient deficiency in Kandhamal district

Nutrient	Deficiency (%)
B+S	39.83
Zn+S	3.60
Zn+B	5.70
Zn+B+S	22.86

The interrelationship between various micronutrients and other soil properties were analyzed and presented in table 5. It indicated negative correlation of pH with soil micronutrients *viz.* Fe, Mn, Zn and positive correlation of extractable Cu, S with OC of soil.

Table 5. Correlation coefficient of different soil parameters with extractable secondary and micronutrients of Kandhamal soils

	pH	EC	OC	Fe	Mn	Cu	Zn	B	S
pH	1								
EC	0.407	1							
OC	0.155	0.499	1						
Fe	**-0.473**	0.005	0.050	1					
Mn	-0.183	0.041	0.283	0.415	1				
Cu	0.008	0.445	**0.626**	0.165	0.250	1			
Zn	-0.119	0.165	0.250	**0.349**	0.168	**0.387**	1		
B	0.017	0.173	0.031	0.152	0.099	0.026	0.181	1	
S	0.140	0.369	**0.395**	0.009	0.071	**0.349**	0.141	0.126	1

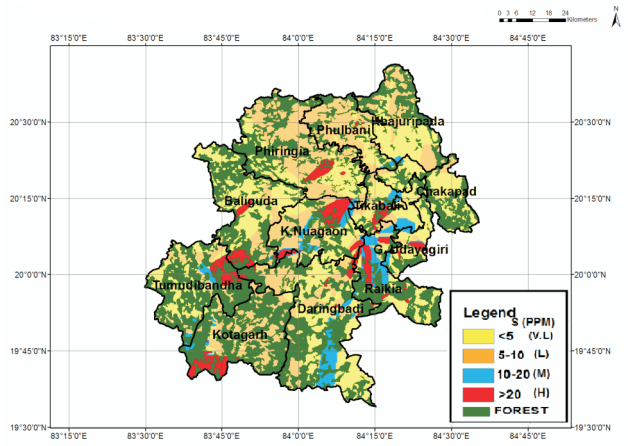

Fig.1 Digitized sulphur content map

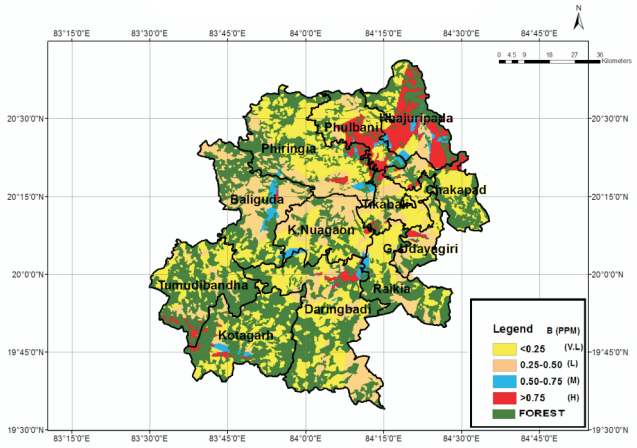

Fig.2 Digitized Boron content map

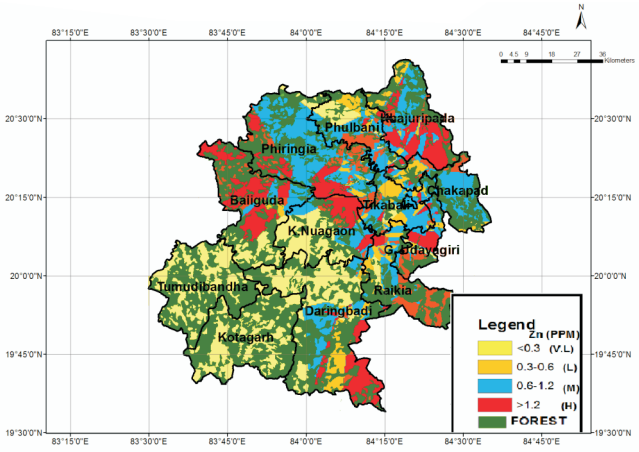

Fig. 3 Digitized zinc map

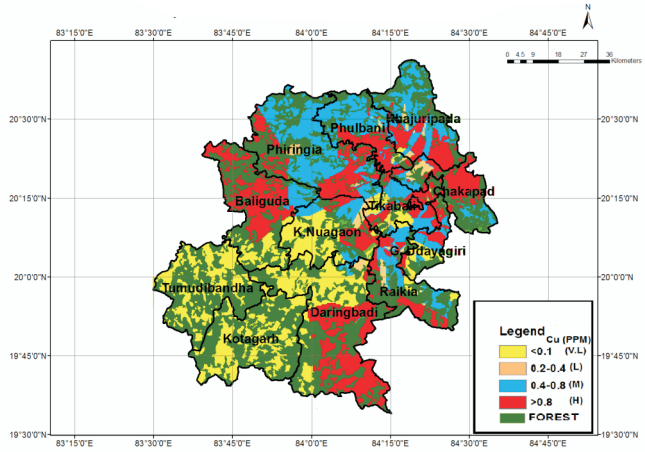

Fig.4 Digitized copper map

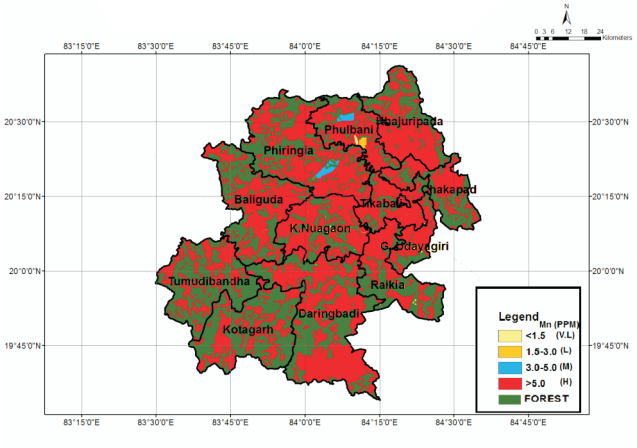

Fig.5 Digitized manganese map

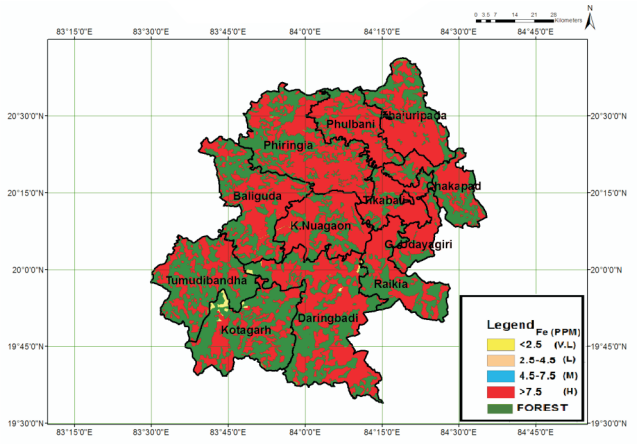

Fig.6 Digitized iron map

Conclusion

Kandhamal soils exhibited high sulphur deficiency followed by boron and zinc. Hence crop management practices should include application of these maturites for higher crop production. Application of S @ 20-40 kg through gypsum, phosphogypsum, bentonite sulphur is recommended along with NPK fertilizers for higher production. Soil fertility maps developed can help farmers, scientists, agriculture officers, etc. in crop and soil management and serve as a reference nutrient map.

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