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Short Research Article

GPS and GIS Based Delineation of Soil Micro and Secondary Nutrient Deficient-sufficient Areas of North Western Plateau Zone of Odisha, India

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Abstract

Assessment and delineation of secondary and micronutrients plays pivotal role in sustainable agriculture. Blanket application of micronutrient fertilizers without the knowledge of native nutrient status may result in nutrient deficiency or toxicity. Since there exists a narrow gap between deficiency and toxicity range of micronutrients so judicious application is essential. Precise analysis by skilled persons and sophisticated instruments poses a drawback in its routine analysis at different places. AICRP on micronutrient project is undertaking analysis of micro and secondary nutrients precisely with precise collection soil sampling based on GPS to quality analysis through expert scientists. The present paper focuses on status of micro and secondary nutrients of Deogarh district of Odisha representing the north western plateau zone. From analysis of 208 no of georeferenced samples collected from 3 blocks of Deogarh highest deficiency of B to the extent of 90% of samples was observed followed by available Sulphur and DTPA extractable Zn. Whereas soils were quite sufficient with respect to Fe, Mn, Cu. Digitized soil fertility maps were prepared by using ARC GIS software which clearly delineated the district into zone of micro nutrient deficiency and sufficiency. These maps will be helpful for the farming community of the study zone to use properly the secondary nutrients and micro nutrients for different crops thereby saving costly inputs with increase in production, productivity, crop quality.

1. Introduction

Micronutrients receive less attention in nutrient management and fertiliserresearch, development and extension (R, D & E) than macronutrients for the understandable reason that usage of micronutrients in crop production is lower. However, there is increasing evidence that the proportion of nutrient management R, D & E allocated to micronutrients is insufficient given their importance Bell and Dell, 2008. Since there exists a narrow gap between deficiency and toxicity range of micronutrients so judicious application is essential. In agriculture, global positioning system (GPS) and geographic information system (GIS) technologies have been adopted for better management of land and other resources for sustainable crop production (Palaniswami et al., 2011). Present day soil sampling by GPS can provide a basis for developing site specific nutrient management followed by development of soil fertility maps which can serve as a resource material for agriculture officers, farmers, crop growers to know the fertility status of their land with respect to a particular nutrient. The modern day space age technologies can be adopted for speedy dissemination of the research results on optimum doses of nutrients for maximum farm profitability (Singh et al., 2005) to scientists, industry personnel, extension workers and farmers. One of them is the use of soil fertility maps for fertilizer recommendation with a support to calculate fertilizer doses based on soil test values interactively. Inventory of the available macro and micronutrient status of the soils help in demarcating areas where, the application of particular nutrient is needed for profitable crop production (Sood et al., 2009).

In Odisha visual symptoms of deficiency/toxicity of some secondary and micronutrients on crops has been observed at a number of locations. Hence, a systematic study was carried out to generate information on extent of secondary and micronutrient deficiency or toxicity areas under different soil types through Geographic Information System (GIS). The present study was undertaken for north western plateau zone of Odisha to assess the surface distribution status of secondary and micronutrients in soils and plants, to identify and delineate areas of micronutrient deficiency and sufficiency zones by the use of GPS and GIS with generation of soil fertility maps

to utilize the current soil status in site specific or need based nutrient management thereby saving the costly input as well as maintaining soil health.

2. Materials and Methods

2.1. Study area

North western plateau zone is one of the important agro-climaticzone of the state Odisha. This agro-climatic zone covers districts like Deogarh and Sundergarh. Deogarh district is situated in the mid-northern part of Odisha represents the north western plateau zone. It is surrounded by Sundargarhdistrict in the north, Angul district in the east and south and Sambalpur district in the west. Extending over an area of 294,000 ha, it occupies 1.9% of the state's area. It receives 1014 mm of average annual rainfall. The district has only one Sub-division (Deogarh) and three Blocksnamely Teleibani, Reamal and Barkote. The most important river flowing through this district is Brahmani.

This zone is composed of very high hills frequently with elevation of 2000 m amsl. The district has three Blocks namely Tileibani, Reamal and Barkote mostly drain to the river Brahmani. The lands of the district have very high degree of slope. The elevation gradually decreases on the south eastern part on either side of the river Brahmani. Between the high hill ranges there are long narrow valleys with well drained and productive lands mostly running in west-eastdirection.

The agricultural land of the district can be marked to have five land form such as hill, ridges, valley, leave and stream terrace which can be further divided into different land types and subland types with district physiographic units. However, broadly these can be classified as high land, medium land and low land. Major soils found in Debgarh district are Red and yellow soils and Black soils. Major crops grown in these soils are Rice and sesamum during *kharif* many vegetables including Onion during *rabi*.

2.2. Soil sampling

To know the nutrient status of soils with respect to secondary and micronutrients 208 no of surface soils were collected during post *rabi* 2014−15 well distributed throughout the 3 blocks with the help of hand held global positioning system (GPS) (Garmin Ltd.) along with 17 no of plant samples. GPS based soil samples from 2 km grid were collected from cultivated fields with recording of latitude, longitude points of the spots keeping minimum 25 samples per block.

2.3. Soil analysis

Soil samples were air dried, processed, sieved and analysed for various micro and secondary nutrients. For analysis of soil samples standard procedures were followed. Determination of soil properties like pH and EC was done on 1: 2.5 soil water ratio (w/v) suspension using pH meter and EC meter following half an hour equilibrium (Jackson, 1973). 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 by 0.15% $CaCl_2$ its content was determined spectrophotometrically using $BaCl_2$ as outlined by Chesnin and Yien (1951). The soils were extracted with DTPA (pH 7.3) extracting solution for estimation of Fe, Mn, Zn and Cu by Atomic absorption Spectrophotometers (AAS) as per Lindsey and Norvell (1978). Hot water soluble Boron by Berger and Trough (1939) followed by colorimetric estimation by using Azomethin H indicator method of (John et al., 1975).

Plant samples were washed with water, air dried, oven dried, grinded, acid digested for nutrient analysis as per standard methods. Total B in plant samples were analysed by dry ashingprocedure.

3. Results and Discussion

3.1. Distribution of basic soil parameters

Analysis result of 208 samples for basic soil properties like pH, EC and OC is presented in Table 1.

Table 1: pH, EC and organic carbon content of soils of Deogarh district

Blocks		pH (1:2.5)	EC (dS m^{-1})	OC (%)
Barkote	Range	4.13−7.89	0.001−0.87	0.15−2.10
	Mean	5.10	0.14	1.34
Teleibeni	Range	4.31−7.39	0.027−0.918	0.04−1.27
	Mean	5.40	0.12	0.56
Reamal	Range	4.54−8.92	0.035−0.469	0.44−1.50
	Mean	6.28	0.16	0.86
Overall	Range	4.08−8.92	0.01−0.92	0.02−2.10
	Mean	5.43	0.14	0.82
	Strongly acidic (<5.5)	68%		Low (29%)
	Acidic (5.5−6.5)	16%		Medium (20%)
	Neutral (6.5−7.5)	11%		High (51%)

Soil pH of Deogarh district varied from 4.08 to 8.92 with mean value of 5.43 indicating acidic soils. Out of 208 samples 68% of samples were strongly acidic, 16% acidic, 11% neutral. Electrical conductivity of Deogarh soils varied from 0.001 to 0.92 dS m^{-1} with mean of 0.14 dS m^{-1} indicating mostly non-saline. Organic carbon status of Deogarh soil varied from 0.02 to 2.10% with mean value of 0.82%. Twenty nine (29%)

percent of soils were low in OC, 20% soils are in medium and 51% high in OC due to addition of forest vegetation indicating wider variability in OC status of western Table l and zone.

3.2. Secondary nutrient status of Deograh soils

Available Sulphur status of Deogarh soil varied from 0.65 to 127.5 mg kg^{-1} with mean of 18.78 mg kg^{-1} indicating medium status of Av. S. Overall 40% of soils of Deogarhwere deficient in Sulphur. Out of 3 blocks Teliebeni showed highest S deficiency of 73% whereas it was <20% in other two blocks. Sulphur deficiency under this zone may be attributed to leaching loss of mineralized sulphate sulphur due to its topographic position(Figure 1).

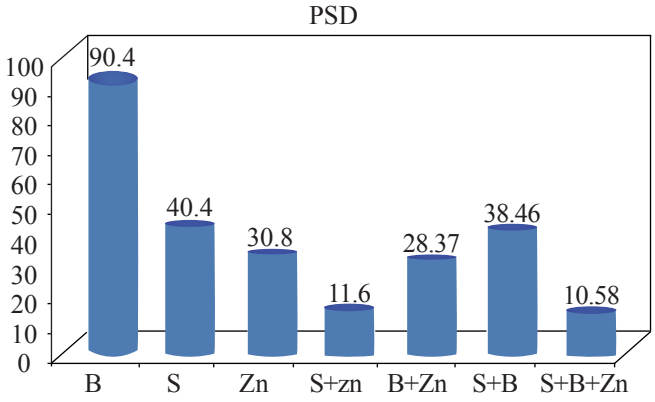

Figure 1: Digitized Sulphur fertility Map of Deogarh

3.3. Surface distribution of micro nutrient status of deograh soils

DTPA extractable micronutrient status for 3 blocks of Deogarh district is presented in Table 2. DTPA extractable Zn status of soils varied from 0.06 to 3.20 mg kg^{-1} with mean of 0.95 mg kg^{-1}. Thirtyonepercent (31%) soils were found to be deficient or low in Av. Zn (Figure 2). Zinc deficiency under highly acidic and high Fe content may be attributed to the fact that high amount of Fe had activated the formation of insoluble Zn-Fe complex or precipitates of $ZnFe_2O_4$ (Franklinte Type) or complexing of Zn with organic matter (Fulvic acid and humic fractions) thereby causing Zn deficiency (Das, 2007). DTPA extractable Cu content of Deogarh varied from 0.63 to 9.55 mg kg^{-1} with mean value of 3.45. No Cu deficiency was found in Deogarh soils. DTPA extractable Fe content of soils varied from 8.76 to 427.12 with mean value of 116.85 mg kg^{-1} and all soils are quite sufficient in Fe status. DTPA extractable Mn content of soils varied from 3.28 to 301.36 mg kg^{-1} with mean value of 58.67 mg kg^{-1} and medium to high status were observed for soil Mn.

Hot water soluble boron content of Deogarh soils varied from 0.01−1.74 with mean of 0.25 mg kg^{-1}. About 90 of samples analyses showed deficiency. All three blocks showed >80% B deficiency (Figure 3)

Deficiency of S, Zn and B were mostly found in soils of Deogarh which was in order of B>S>Zn and sufficient quantity of Fe, Mn,Cu were present. Hence deficiency of boron in Deogarh district was highest which can pose a threat for vegetable and pulse production of the district. Dizitised soil fertility maps were developed for micro and secondary nutrients by using Arc GIS software which clearly delineated the district into deficient and sufficient zones which will be helpful for proper crop planning. Extent of Multinutrient deficiency is presented in Figure 4.

3.4. Micro-secondary nutrient content in plant tissues

Eighteen no of plant samples were collected from Deogarh district which were mostly oilseeds, vegetables, greens

Table 2: Micro and secondary nutrient status of soils of Deogarh district

Block		Zn	Cu	Fe	Mn	B	S
		(mg kg^{-1})					
Barkote	Range	0.33−3.2	1.93−6.84	26.48−427.12	8.86−301.4	0.01−1.73	1.74−119.51
	Mean	1.16	3.68	144.52	68.59	0.29	27.51
	PSD	9.61	-	-	-	90.4	19.2
Teleibeni	Range	0.056−2.95	0.896−9.55	20.92−413.92	4.72−225.96	0.016−0.56	0.65−127.51
	Mean	0.95	3.66	123.48	79.86	0.12	14.58
	PSD	26.19	-	-	-	95.2	72.6
Reamal	Range	0.21−1.87	0.63−5.54	8.76−178.96	6.28−138.24	0.02−0.81	1.30−67.51
	Mean	0.70	3.02	71.78	46.20	0.31	19.63
	PSD	52.11	-	-	-	84.5	18.3
Overall	Range	0.06−3.20	0.63−9.55	8.76−427.12	3.28−301.36	0.01-1.74	0.65−127.51
	Mean	0.95	3.45	116.85	58.67	0.25	18.78
	PSD	30.8	-	-	-	90.4	40.4

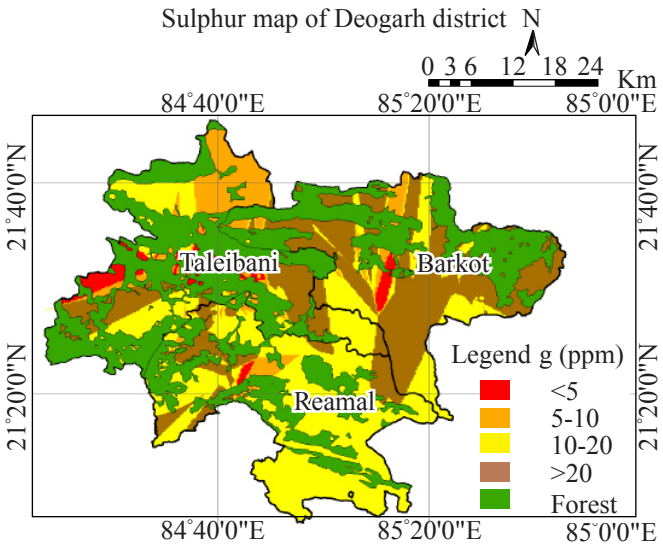

Figure 2: Digitized Zinc fertility Map of Deogarh

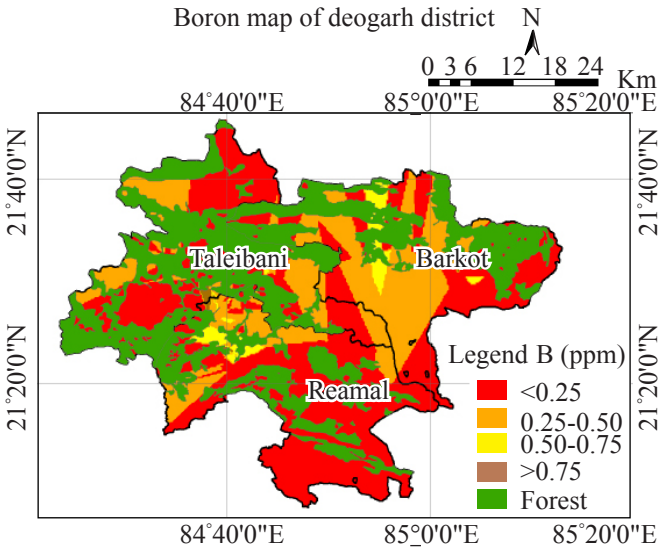

Figure 3: Digitized Boron fertility map of Deogarh

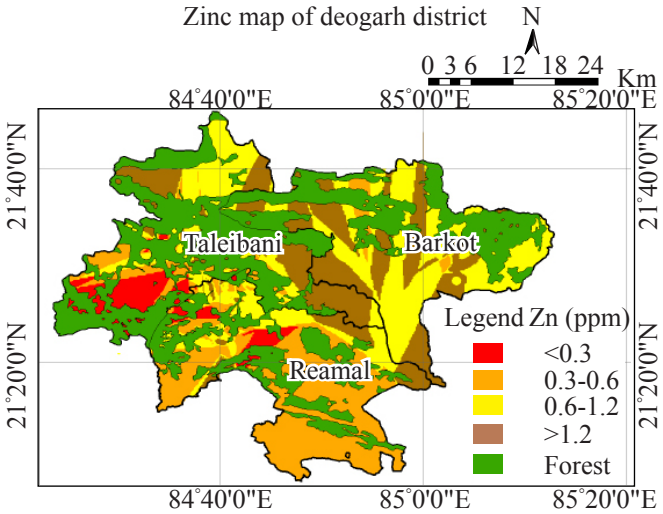

Figure 4: Single and multinutrient deficiency in soils of Deogarh district

collected during soil sample collection at their respective stages of growth and analysed for various micro and secondary nutrients range and mean of which is presented in Table 3 .More than 90% of samples deficiency of S, B, Zn were observed indicating hidden hunger for these nutrients.

Table 3: Micronutrient content in plant tissue of Deogarh

	No. of sample	Range (mg kg^{-1})	Mean (mg kg^{-1})	PSD (%)
S	18	5.5-238.9	48.9	94
B	18	4.4-13.1	7.3	100
Zn	18	0.3-10.2	3.17	100
Cu	18	ND		ND
Fe	18	21-180.9	59.74	67
Mn	18	0.1-72.5	8.70	94

4. Conclusion

Micro-secondary nutrient status of surface soils of western Table l and zone of Odisha suffers from highest deficiency of B followed by Zn and secondary nutrients available Sulphur. No deficiency of Fe, Mn and Cu were noticed in soils of this zone. Extent of multinutrient deficiency was in order of S+B>B+Zn>S+Zn>S+B+Zn. GPS and GIS based soil fertility maps help farmers, scientists, planners and students in providing online soil test based fertilizer recommendation for intensive and sustainable crop production

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