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RESEARCH PAPER

Evaluation of soil fertility status in red and yellow soil of Navagarh block in Janjgir-Champa district of Chhattisgarh

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Abstract : A Study was undertaken to evaluate the fertility status of Navagarh block, Janjgir-Champa district, Chhattisgarh, covering 112 villages of Navagarh block and 78 villages under red and yellow soil during 2011-2012. The systematic collection of samples in geo–referenced surface (0-0.15,m depth) soil samples from 1984 sites representing, red and yellow soil using Global Positioning System and mapped on 1:4000 scale. The samples were analyzed for DTPA-extractable zinc, copper, iron and manganese and available nitrogen, phosphorus and potassium content for delineation the fertility status in relation to salient physico-chemical characteristics. The statistical description of soil characteristics indicated that the pH of the soils varied from 4.5 to 7.2 (mean- 5.73). The electrical conductivity of soil-water suspension ranged from 0.05 to 0.78, dS m^{-1} (mean- 0.16, dS m^{-1}). The DTPA-extractable copper content ranged from 0.16 to 10.84, mg kg^{-1} (mean- 2.13, mg kg^{-1}). The available Mn, Fe and Zn content ranged from 0.32 to 64.8 (mean- 31.57), 3.24 to 51.42 (mean- 26.52) and 0.16 to 5.4, mg kg^{-1}(mean- 0.9 mg kg^{-1}), respectively. These results indicated that zinc is likely to constraint for crop production in soil of Navagarh block. A positive significant correlation was found between pH and EC. Further,the available copper, manganese and iron content showed high status, whereas about 34.42 per cent area under soils delineated as deficient in available zinc content.

Key Words : Fertility status, Micronutrients, Red and yellow soil (*Inceptisol*)

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INTRODUCTION

Soil fertility management will ultimately consider all aspects of soil – plant relationship and pollution of the environment as well. Soil fertility may be defined as the soil system's nutrient supplying capacity. It helps in adopting appropriate measures for overcoming various limitations and at the same time ensures optimum crop production.

Soil micro nutrients are an essential as primary and secondary nutrients for the development of crop growth. The addition of micro nutrients to fertilizers in the optimum amounts and in degraded soils ensures the sustainability of cropping through balanced nutrition and ultimately sustainable development of the fertilizer industry.

Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have high degree of spatial variability resulting from the combined effects of physical, chemical or biological processes (Goovaerts, 1998). However, major constraints impede wide scale adoption of soil testing in most developing countries. In India, these include the prevalence of small holding systems of farming as well as lack of infrastructural facilities for extensive soil testing (Sen *et al.*, 2008).

The advent of information technology have provided

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tools like Global Positioning System (GPS), Remote sensing, Simulation modeling and Geographical Information System (GIS), which help in collecting a systematic set of georeferenced samples and generating the spatial data about the distribution of nutrients (Sharma, 2004). The maps generated through remote sensing helps in delineating the homogenous units to decide the sampling size and thereby saving a lot of time. This will also helps to monitor the changes in micronutrients status over a period of time as sampling sites can be revisited with the help of GPS which is otherwise difficult in the random sampling (Sood *et al.,* 2004).

The variability in fertility caused by application of fertilizers in individual farms is one factor that is difficult to account. However, it is possible to measure the natural variation in soil fertility by considering the factors which influence it. Slope, topography, relief and soil types can account for most of the natural variation in fertility. It will be of great significance if soil test crop response based recommendation can be provided even on this basis. More site specific recommendations can still be provided on the basis of field soil testing to farmers who are applying very high doses of fertilizer and who show interest on testing their soils. The soil testing results indicate nothing about the potential of soil to produce or amount of nutrients to be added to achieve a desired yield (Melsted and Peck, 1977). The interpretation of test results is carried out by correlating data obtained by analysis of soil samples with known field crop response.

Chhattisgarh state is carved out of the erstwhile Madhya Pradesh. It lies between $17^0 46' – 24^0 8'$ N latitude and $80^0 15' – 84^0 24'$ E longitude. The state measures 640 km from North to South and 336 km from East to West with a total area of 1,35,194 km. The total geographical area of the State is 1,36,034.3 km. The state shares its boundaries with the 6 Indian states *i.e.* Madhya Pradesh on the northwest, Uttar Pradesh on the north, Jharkhand on the north-east, Orissa on the south-east, Andhra Pradesh on the south and Maharashtra on the south-west. Chhattisgarh state has four major soils type *i.e. Entisol*, *Inceptisol*, *Alfisol, Vertisol* in whole area and very little amount of *Mollisols* at Manpat area of Ambikapur and forest area of Baster plateau. Almost all soils are deficient in nitrogen and phosphorus and medium to high in potassium. Zinc deficiency is commonly observed in *Alfisols* and *Vertisols* of this region. The red and yellow colors of most soils are caused by Fe compounds, so most soils possess enough Fe for plant needs. The fact that Fe gives the soil its color means that Fe remains behind while other more soluble elements are removed by leaching, due to heavy rainfall.

The district Janjgir- Champa is situated in the center of the Indian state of Chhattisgarh and so it is considered as the "*heart of Chhattisgarh*". The Janjgir-Champa district is a major producer of food grains in the state of Chhattisgarh. The Hasdeobango project has been considered as life supporting canal for the district Janjgir-Champa. Under this project 75per cent area of the district will be covered for irrigation. The district head quarter of Janjgir-Champa is in Janjgir-Champa, which is situated on national highway no. 200. Janjgir-Champa is 65 km away from Bilaspur and 175 km from state capital Raipur through road route.

Study area :

Janjgir-Champa district covers an area of 446674 ha and it is situated in central part of Chhattisgarh state lying between $82^0 2'$ to $82^0 3'$ ^{E} longitude and $21^0 6'$ to $22^0 4'$ ^{N} latitude and 294.4 m high from mean sea level. The normal rainfall is 1478 mm and average rainfall 1157mm. The average maximum and minimum temperatures are 49 and 08° C. Out of the total geographical area, the net sown area is 3,23,599 ha and forest area is 79,439 ha. Total cropped area during *Kharif* is 2,59,215ha and during *Rabi* is 6,43,84 ha. Total irrigated area is 2,15,128 ha. The district is surrounded by the Raigarh district on the east and in the north Korba and Bilaspur district. Paddy, Kodo, Arhar, Wheat, Lakhdi (Tiwara) are the main emerging crops of the district. The district is divided into 10 tahsil and 9 developmental blocks. The tahsils are Janjgir- Champa, Akaltara, Baloda, Nawagarh, Champa, Pamgarh, Sakti, Jaijaipur, Malkharoda and Dabhara. The development blocks of Janjgeer - Champa district are Navagarh, Baloda, Akaltara, Pamgarh, Bamhinidih, Sakti, Jaijaipur, Malkharoda, and Dabhara. The total villages in the District are 915 including 2 forest villages. Navagarh block is headquarter prominent town in Janjgir-Champa district of Chhattisgarh. Janjgir the district headquarters is around 10 km north-east. Navagarh is located at Janjgir-Champa district lying between 21°57' 63"N latitude to 82°36'16"E longitudes. It has an average elevation of 288 m. Systematic survey is carried out for evaluation the soil fertility status of Navagarh Block of Janjgir-Champa district, a surface (0-15 cm, depth) soil samples were collected from 112 villages of Navagarh block and 78 villages under red and yellow soil of Janjgir-Champa district, in a grid of every 10 ha. Area by using G.P.S. system. The number of soil samples will be classified based on area of agricultural land and types of soil. Cadastral map of each village is acquired from revenue department for the above purpose.

MATERIAL AND METHODS

Soil samples collected from the study area were dried and crushed with the help of wooden rod and passed through 2 mm sieve and then used for the determination of soil pH, and micronutrients content by adopting standard laboratory method. Soil pH was determined by glass electrode pH (Piper, 1967), electrical conductivity with Solu-bridge method (Black, 1965). The micronutrients Zn, Cu, Fe and Mn were extracted by using 0.005M diethylene triamine penta acetic acid (DTPA), 0.01M calcium chloride dehydrate and 0.1M triethanol amine buffered at pH 7.3 (Lindsay and Norvell, 1978) and concentrations were analyzed by atomic absorption spectrophotometer 4129. The data on available Fe, Cu, Mn and Zn of soils were characterized for deficient and adequate status using the threshold values 4.5 mg kg^{-1} for Fe, 0.2 mg kg^{-1} for Cu, (Katyal and Randhawa, 1983), 3 mg kg^{-1} for Mn (Shukla and Gupta,1975) and 0.6 mg kg^{-1} for Zn (Katyal,1985).The samples were categorized as per the rating limit.

RESULTS AND DISCUSSION

The result obtained from the research work is presented in this chapter on the basis of which assessment of the fertility status of the red and yellow soil of Navagarh block have been made. Micronutrients (Zn, Fe, Cu and Mn) are important soil elements that control its fertility. Soil fertility is one of the important factor controlling yields of the crops. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agriculture production. Soil testing is the key to fertility management while reclamation and rehabilitation of degraded lands is strategic to maintain over all soil health. The result achieved from the present investigation is presented in this chapter determining the assessment of the soil fertility status of the Navagarh block of Janjgir-Champa district. The soil samples were analysed for the physico-chemical properties *i.e.* pH, electrical conductivity and available nutrient (Fe, Cu, Zn and Mn) content. The soils under study were evaluated for nutrient availability in respect of the major elements, the nutrient index figures were worked out and the soil was categorized to different fertility units. DTPA- extractable content of Zn, Fe, Cu and Mn elements determined the micronutrient status of soils. The salient significant correlation findings of the investigation are also presented in systematic manner.

Physico-chemical characteristics :

Soil reaction (pH) :

The red and yellow soil samples of the study area were determined for pH (Table 1) and observed in the range of 4.5 - 7.2 with the mean value of 5.73. pH estimation from total 1984 soil samples of Navagarh block covering about 78 villages was done and it was observed under strongly acidic 5.54 per cent, under moderately acidic 66.07 per cent under slightly acidic 20.52 per cent and only 7.87 per cent samples were categorized under neutral soil. (Table 3) Similar results were also noted by Kher and Khajuria (2005), Jena *et al*. (2008), Jatav (2010) and Shukla (2011). The lowest average pH 5.0 of the Chorgaon village was under moderately acidic in reaction as compared to highest pH *i.e.* 6.7 in Pachari village of the Navagarh block (Appendix-I).

Electrical conductivity (EC) :

The electrical conductivity (EC), varied from 0.05 to 0.78 dS m^{-1} in red and yellow soil with a mean value of 0.16 dS m^{-1} at 25^{o}C (Table 4) of the Navagarh block. The total salt content of these soils, expressed as EC, are categorized as <1, 1 to 2, 2 to 3 and >3 dS m^{-1}. The normal EC may be ascribed to leaching of salts to lower horizons due to its light textured nature and

Table 1: Salient soil properties of the study area

Soil characteristics	Range	Mean	S.D
pH (1:2.5,Soil:water)	4.5-7.2	5.73	± 0.55
E.C. (dS m^{-1})	0.05-0.78	0.16	± 0.08
Available Cu (mg kg^{-1})	0.16-10.84	2.13	±1.78
Available Fe (mg kg^{-1})	3.24-51.42	26.52	±10.91
Available Mn (mg kg^{-1})	0.32-64.80	31.57	±14.59
Available Zn (mg kg^{-1})	0.16-5.40	0.90	±0.78

Table 2: Limits for the soil test values used for rating the soil

Classification for pH values				
Strongly acid	Moderately acid	Slightly acid	Neutral	Slightly alkaline
<5.0	5.0-6.0	6.1-6.5	6.6-7.5	7.6-8.5

Classification for total soluble salt content (EC as dS m^{-1})			
Normal	Low salinity	Medium salinity	High salinity
<1	1-2	2-3	>3

Micronutrients	Deficient	Sufficient	High level
Av. Fe (mg kg^{-1})	<4.50	>4.50	>9.00
Av. Mn (mg kg^{-1})	<3.50	>3.50	>7.00
Av. Cu (mg kg^{-1})	<0.20	>0.20	>0.40
Av. Zn (mg kg^{-1})	<0.60	>0.60	>1.20

also due to excessive irrigation.

Data presented in Table 4 reveal that in Navagarh block 100 per cent soil samples were found under <1 dS m-l classes in red and yellow soil.

The results have shown that all the EC values were under normal range (<1.0 dS m^{-1}), therefore, these soils were denoted as non-saline and it was reported by Bali *et al.* (2010), Jatav (2010) and Shukla (2011). The normal EC may be ascribed to leaching of salts to lower horizons due to the light textured nature of the soils and ultimately results in higher macroporsity.

Status of available micronutrients in soils :

The data pertaining to status of available zinc, copper, iron and manganese of Navagarh block under investigation are summarized in Table 5 to 8.

Available iron status :

The DTPA-extractable Fe content of red and yellow soil under study ranged from 3.24 to 51.42 mg kg^{-1} with mean 26.52 mg kg^{-1} (Table 1).

Considering 4.5 mg kg^{-1} (Table 5) DTPA-extractable Fe as critical limit (Lindsay and Norvell, 1978), the data reveals that 5.59 per cent soil samples were found to be sufficient in available Fe content and 93.95 per cent in higher level and only 0.45 per cent soil samples were found to be deficient level (Table 5).

High available Fe content in red and yellow soil of Navagarh block might be due to its topography relief and cultivation of rice, which induced an erotic prolonged submergence coupled with reducing conditions. The soil in study area was some deficient in Fe as the amount of Fe required by crops is being released by Fe bearing minerals in

Table 3: Category of soil samples under different pH rating of Navagarh block

Classes	Red and yellow soil		
	Limit	No. of samples	Per cent samples
Strongly acid	<5.0	110	5.54
Moderately acid	5-6.0	1311	66.07
Slightly acid	6.1-6.5	407	20.52
Neutral	6.6-7.5	156	7.87
Slightly alkaline	7.6-8.5	0	0
Total		1984	100

Table 4: Electrical conductivity of surface soil in Navagarh block

Limits of EC(dS m^{-1})	Red and yellow soil	
	No. of samples	Per cent samples
Normal <1	1984	100
Low salinity 1-2	0	0
Medium salinity 2-3	0	0
High salinity >3	0	0
Total	1984	100

Table 5: Distribution of available iron status in surface soil of Navagarh block

Rating of available Fe (mg kg^{-1})		Red and yellow soil	
		No. of samples	Per cent samples
Deficient	<4.5	9	0.45
Sufficient	4.5-9.0	111	5.59
High level	>9.0	1864	93.95
Total		1984	99.99

Table 6: Distribution of available copper status in surface soil of Navagarh block

Rating of available Cu (mg kg^{-1})		Red and yellow soil	
		No. of samples	Per cent samples
Deficient	<0.2	0	0
Sufficient	0.2-0.4	95	4.78
High level	>0.4	1889	95.21
Total		1884	99.99

these soil. The pH had reverse effect on the availability of Fe content in soil. Gajbhiye *et al.* (1993) in soil of Saongi watershed of Maharashtra, Rajeswar *et al.* (2009) in soil of Garikapadu of Krishna district of Andhra Pradesh have also reported the similar trends in available Fe content (Jatav, 2010; Shukla, 2011).

Available copper status :

The DTPA-extractable Copper content of soils under study varied from 0.16 to 10.84 mg kg^{-1} with mean value 2.13 mg kg^{-1} (Table 1).The results are in conformity with the findings of Singh and Raj (1996) in soil of Himachal Pradesh and similar results were also reported by Singh and Jain (1971), Meena *et al.* (2006), Yadav and Meena (2009) and Singh *et al.* (2009) and Shukla (2011).

Considering the rating (<0.2 mg kg^{-1})of available Cu as deficient, (0.2-0.4 mg kg^{-1}) sufficient, (>0.4 mg kg^{-1}) high level DTPA-extractable copper as critical limit (Follett and Lindsay, 1970) in Table 2 and 6, only 4.78 per cent soil samples were found to be sufficient in available content of copper, and 95.21 per cent soil sample found to be in higher level (Table 6). Maximum per cent of soil samples were found under high level in available Cu content with a model class of >0.4 mg kg^{-1} DTPA-extractable Cu (Table 6). Kumar *et al.* (2009), Rajeshwar *et al.* (2009), Meena *et al.* (2006) and several other workers reported available copper with similar range.

The DTPA-extractable Mn content of soil under study (red and yellow soil) varied from 0.32 to 64.8 mg kg^{-1} with mean value of 31.57 mg kg^{-1} (Table 1).

Considering the rating (<3.5 mg kg^{-1}) of available Mn as deficient, (3.5-7.0 mg kg^{-1}) sufficient, (>7.0 mg kg^{-1} (Table 2) DTPA-extractable Mn as high level of critical limit (Lindsay and Norvell, 1978), the data presented in Table 7, revealed that 2.02 per cent of soil samples found to be deficient, 3.12 per cent of samples were sufficient and 94.86 per cent samples high in available Mn in soil of Navagarh block. These results are in conformity with the finding of Ghosh and Sarkar (1994). The Mn bearing minerals in the parent material might be the reason for higher Mn content in the soils and due to better supply of Mn to rice in flooded soil as Mn is soluble in relatively acidic and reduced soil condition (Mandal and Haldar, 1980; Sharma *et al.*, 2001; Jatav, 2010; Shukla, 2011).

Table 7 : Distribution of available manganese status in surface soil of Navagarh block

Rating of available Mn (mg kg^{-1})		Red and yellow soil	
		No. of samples	Per cent samples
Deficient	<3.5	40	2.02
Sufficient	3.5-7.0	62	3.12
High level	>7.0	1882	94.86
Total		1984	100.00

Table 8 : Distribution of available zinc status in surface soil of Navagarh block

Rating of available Zn (mg kg^{-1})		Red and yellow soil	
		No. of samples	Per cent samples
Deficient	<0.6	683	34.42
Sufficient	0.6-1.2	1023	51.56
High level	>1.2	278	14.02
Total		1984	100.00

Table 9: Averages of available micronutrients in different ratings of pH

	Limit	No. of samples	Available micronutrients (mg kg^{-1})			
			Fe	Cu	Mn	Zn
	<5.0	110	27.6	2.4	31.1	0.9
pH	5-6.0	1311	27.1	2.1	33.1	0.9
	6.1-6.5	407	24.9	2.0	29.0	0.8
	6.6-7.5	156	25.0	2.3	25.7	0.8

Table 10 : Correlation co-efficients (r) between physico-chemical properties and DTPA-extractable Zn, Cu, Fe and Mn in red and yellow of Navagarh block

Soil properties	Available micro-nutrients			
	Cu	Mn	Fe	Zn
pH	-0.023	-0.129**	-0.150**	-0.069*
EC	-0.039	-0.073*	-0.071*	-0.014

* and ** indicate significance of values at P=0.05 and P=0.01, respectively

Available zinc status :

The DTPA-extractable Zn content of soils under study varied from 0.16 to 5.4 mg kg^{-1} with mean value of 0.9 mg kg^{-1} (Table 1). Considering the soil test rating for DTPA-extractable Zn (<0.6 mg kg^{-1} as deficient, 0.6-1.2 mg kg^{-1} as sufficient and >1.2 mg kg^{-1} as high level) the critical limit (Table 2) for Zn deficiency (Lindsay and Norvell, 1978), the soil samples were found to be 34.42 per cent in deficient, 51.56 per cent in sufficient and only 14.01 per cent samples were found to be high level in available content of Zn (Table 8) and required Zn application for optimum production and to get full benefit from N, P and K fertilization. In well drained aerated calcareous soils zinc exists in oxidized state and their availability becomes low. The results are in conformity with the finding of Sharma and Chaudhari (2007) in soils of Solan district in North-West Himalayas and also similar findings by Rajeswar *et al.* (2009). Similar results were also reported by Garikapadu of Krishna district of Andhra Pradesh and Singh *et al.* (2009) in the soils of Ghazipur district of Uttar Pradesh.

Soil reaction (pH) :

Soil pH showed positive relationship with available N, P and K. Since the average pH of the soil under study exhibited near acidic to neutral reaction, hence the major nutrients showed synergistic effect with favorable soil pH.

Available Fe, Mn, Cu and Zn content in relation to soil characteristics soil reaction (pH) :

In general the data presented in Table 9 show that pH is inversely related with DTPA-extractable Zn, Mn, Cu and Fe content. The availability of DTPA- extractable Zn content show medium values and Cu, Mg and Fe content show high values due to their solubility effects.

Relationship between soil characteristics and DTPA-extractable Zn, Cu, Fe, and Mn in red and yellow soil :

Iron :

The DTPA-Fe showed a negative and significant correlation (r =-0.150**) with pH (Table 10) which confirms the basic chemistry of Fe availability in various pH level of the soil. Talukdar *et al.* (2009), Verma *et al.* (2007), Singh *et al.* (2006) and Somasundaram *et al.* (2009), Jatav (2010), Shukla (2011) also reported significant negative correlation of available Fe with pH of the soil. The correlation of Fe level with EC showed a negative and significant result (r =-0.071*), Similar observations were also observed by Somasundaram *et al.* (2009) and Sharma *et al.* (2006).

Manganese :

Like Fe availability, Mn status also resulted a negative and significant correlation with pH (r=-0.129**), and electrical conductivity (r =-0.073*) (Table 10). The possible reason behind this may be due to the formation of insoluble higher valent oxides of Mn at high pH (Sahoo *et al.,* 1995).

Copper :

A non-significant negative correlation (r=-0.023) was observed between soil pH and available Cu (Table 10). The availability of Cu content show higher values at low pH due to their solubility effects. Similar relation was also observed by several workers (Sood *et al.,* 1995; Jatav, 2010, Shukla, 2011). A negative and non-significant relationship (r = -0.039) found between available Cu and electrical conductivity (Table 10).

Zinc :

A significant and negative relationship (r =-0.069*) was observed with pH (Table 10), thereby indicating the availability of Zn decreased with increase in soil pH. This negative relationship might be attributed to the increased availability of Mn, Zn and Cu under low pH condition which increased solubility of oxides and hydroxides of these micronutrients. Similar relation was also observed by Gupta (1995), Jena *et al.* (2008) and Jatav (2010).

A non-significant and negative relationship (r = -0.014) was observed with E.C. (Table 10). Similar relation was also observed by Sharma *et al.* (2006). Brar *et al.* (1982), Shukla (2011) found that available Cu, Fe and Mn contents were affected by pH and EC.

Conclusion :

It can be concluded from the results under study that the red and yellow soil group of Navagarh block in Janjgir-Champa district of Chhattisgarh was characterized under moderate to neutral in soil reaction and less than one dS m^{-1} soluble salt content comes under safe limit for all growing crops. The organic carbon level exhibited low to medium. The red and yellow soil of the area showed low to medium in available N and P and medium to high level in available K status of the whole soil samples under study. In general, the soil samples were tested sufficient in DTPA-extractable Fe, Mn, Cu, and Zn. Hence, the soils require attention regarding nutrient management practices and regular monitoring of soil health for better crop production.

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