ASSESSMENT AND MAPPING OF SOME IMPORTANT SOIL PARAMETERS INCLUDING SOIL ACIDITY FOR THE STATE OF JHARKHAND (1:50,000 SCALE) TOWARDS RATIONAL LAND USE PLAN

CHATRA DISTRICT

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1. INTRODUCTION

Reliable information on the location, extent and quality of soil and land resources is the first requirement in planning for the sustainable management of land resources. The components of land i.e., soils, climate, water, nutrient and biota are organised into eco-system which provide a variety of services that are essential to the maintenance of the life support system and the productive capacity of the environment. Our land mass is fixed, but the competition among different kinds of uses for this land is increasing because of rapidly rising global population. Therefore, integrated land resource planning and management are required to resolve these conflicts and soil resource survey seems to be a viable means in this process and knowledge of soil fertility status and problems of soils like soil acidity/alkalinity become essential for sustainable land use plan.

Soil fertility is an aspect of the soil-plant relationship. Fertility status of the soils is primarily and importantly dependent upon both the macro and micronutrient reserve of that soil. Continued removal of nutrients by crops, with little or no replacement will increase the nutrient stress in plants and ultimately lowers the productivity. The fertility status of the soils mainly depends on the nature of vegetation, climate, topography, texture of soil and decomposition rate of organic matter. Optimum productivity of any cropping systems depends on adequate supply of plant nutrients. GIS is a versatile tool used for integration of soil database and production of a variety of users specific and user-friendly interpretative maps. This further leads to accurately and scientifically interpret and plan some of the aspects like conservation of organic matter, soil reaction (pH) control and fertilization.

Keeping in view NBSS & LUP, Regional Centre, Kolkata in collaboration with Department of Soil Science and Agricultural Chemistry, BAU, Ranchi, Jharkhand undertook a project entitled "Assessment and mapping of some important soil parameters including soil acidity for the state of Jharkhand (1:50,000 scale) towards rational land use plan" from Department of Agriculture, Govt. of Jharkhand. The major objectives of the project were

- Preparation of districtwise soil acidity maps
- Preparation of districtwise soil fertility maps (Organic carbon, available N, P, K, S and available Fe, Mn, Zn, Cu and B)

The above maps will provide information regarding soil nutrients and soil acidity status for the districts, which will be very useful in identification of site specific problems for planning purposes. The present report deals with the above mentioned objectives of the Chatra district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Chatra district is located in the Hazaribag plateau. It is bounded by the district of Gaya of Bihar state in the north, Palamu district in the west and Latehar in the South and Koderma and Hazaribag district in the East. It has an area of 3706 sq. km and population of 7,90,680 persons (Census of India, 2001). The district comprises one subdivision and ten development blocks viz. Chatra, Simaria, Patrappur, Huntergunj, Itkhori, Tandwa, Kunda, Lawalong, Giddhor and Pratapgarha.

2.2 Physiography, Geology and Drainage

Since the district consists of part of Upper Hazaribag plateau and Lower Hazaribag plateau and northen scarp, it presents diverse physiographic features. It has an elevation of about 450 m. Kalua hill and Lahabar hill forms the higher elevations of the district. Due to scarp landforms some waterfalls are observed in the district. The general slope of the district is from north to south. Geologically the area is comprised with Archean granites and gneisses. In southern part Gondwana rock formation occur in patches. Major rivers flowing in the district are Yamuna, Barki, Chako, Damodar and Garhi.

2.3 Climate

The district receives an annual rainfall of 1250 mm. and most of the rainfall occurs during the rainy season. During winter season the area receive 1 to 2 mm rainfall. The mean annual temperature remains about 25^0C but in summer season it reaches upto 46^0C and in winter season it comes down to 2 to 3^0C.

2.4 Agriculture and Land Use

The major portion of the district is covered by forest (60.4 % of TGA) and has scattered settlement pattern. The forest is full of variety of medicinal plants, kendu leaves, bamboo, sal, teak and other timber species. The district has considerable flat land, which provide suitable site for agricultural use. The hilly areas are mostly under forest with patches of cultivation on scarp areas. Major crops grown in the district are rice, wheat and pulses. Only 12.21 percent area of agricultural use are net irrigated and major source of irrigations are well and tubewells.

Land Use in Chatra District (1997-98)

		Chatra	**Jharkhand**
1.	Forest	60.40 %	29.2 %
2.	Net sown area	12.54 %	22.7 %
3.	Barren and unculturable waste	5.29 %	7.2 %
4.	Non agricultural use	3.28 %	9.9 %
5.	Orchards	1.25 %	2.5 % (Orchards and Pasture combined)
6.	Pasture	0.43 %	
7.	Culturable wasteland	1.24 %	3.5 %
8.	Current and other fallow	15.57 %	25.0 %

Source: Fertilizer and Agriculture Statistics, Eastern Region (2003-2004)

2.5 Soils

The soils occurring in different landforms have been characterised during soil resource mapping of the state on 1:250,000 scale (Haldar et al. 1996) and three soil orders namely Entisols, Inceptisols and Alfisols were observed in Chatra district (Fig.1 and table 1). Alfisols were the dominant soils covering 52.2 percent of TGA followed by Entisols (33.9 %) and Inceptisols (13.0)

Table 1. Soils of the district and their extent

Map unit	Taxonomy	Area ('00ha)	% of TGA
16	Fine, mixed, hyperthermic, Typic Haplustalfs Loamy, mixed, hyperthermic,Lithic Ustorthents	191	5.15
17	Loamy, mixed, hyperthermic, Lithic Ustorthents Fine, mixed, hyperthermic, Typic Rhodustalfs	16	0.43
19	Loamy-skeletal, mixed, hyperthermic,Lithic Ustorthents Fine loamy, mixed, hyperthermic, Typic Haplustepts	41	1.11
20	Loamy, mixed, hyperthermic, Lithic Ustorthents Fine, mixed, hyperthermic, Typic Rhodustalfs	29	0.78
23	Fine-loamy, mixed, hyperthermic, Typic Haplustepts Fine-loamy, mixed, hyperthermic, Typic Haplustalfs	228	6.15
25	Fine, mixed, hyperthermic, Typic Paleustalfs Fine, mixed, hyperthermic, Rhodic Paleustalfs	33	0.89
28	Fine, mixed, hyperthermic, Typic Haplustalfs Fine, mixed, hyperthermic, Aeric Endoaqualfs	20	0.54
30	Loamy-skeletal, mixed, Typic Haplustepts Fine-loamy, mixed, hyperthermic, Typic Haplustalfs	71	1.92
35	Loamy-skeletal, mixed, hyperthermic, Lithic Ustorthents Fine-loamy, mixed, hyperthermic, Typic Haplustalfs	1127	30.41
36	Fine, mixed, hyperthermic, Typic Paleustalfs Fine loamy, mixed, hyperthermic, Typic Rhodustalfs	441	11.90
37	Loamy, mixed, hyperthermic, Lithic Haplustalfs Fine, mixed, hyperthermic, Typic Paleustalfs	3	0.08
38	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Haplustepts	38	1.03
40	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Typic Haplustalfs	191	5.16
41	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine loamy, mixed, hyperthermic Typic Paleustalfs	229	6.18
42	Fine, mixed, hyperthermic Typic Rhodustalfs Fine loamy, mixed, hyperthermic Typic Ustorthents	161	4.34
43	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	82	2.21
44	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Typic Haplustepts	44	1.19
46	Fine, mixed, hyperthermic Aeric Endoaqualfs Fine, mixed, hyperthermic Typic Endoaqualfs	57	1.54
48	Loamy-skeletal, mixed, hyperthermic Lithic Ustorthents Fine, mixed, hyperthermic Typic Rhodustalfs	63	1.70
57	Fine, mixed, hyperthermic Typic Haplustepts Fine loamy, mixed, hyperthermic Aeric Endoaqualfs	59	1.59
65	Loamy, mixed, hyperthermic Lithic Ustorthents Fine loamy, mixed, hyperthermic Typic Haplustepts	16	0.43
66	Loamy-skeletal, mixed, hyperthermic Typic Haplustepts Coarse loamy, mixed, hyperthermic Typic Ustorthents	5	0.13
67	Coarse loamy, mixed, hyperthermic Typic Ustorthents Fine, mixed, hyperthermic Typic Haplustalfs	205	5.53
70	Fine loamy, mixed, hyperthermic Typic Haplustepts Fine, mixed, hyperthermic Aeric Endoaqualfs	56	1.51

Map unit	Taxonomy	Area ('00ha)	% of TGA
77	Fine loamy, mixed, hyperthermic Typic Rhodustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	19	0.51
78	Fine, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Ultic Haplustalfs	22	0.60
79	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Ultic Paleustalfs	143	3.86
81	Fine, mixed, hyperthermic Typic Rhodustalfs Loamy, mixed, hyperthermic Lithic Ustorthents	40	1.08
85	Fine-loamy, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Typic Paleustalfs	29	0.79
86	Fine, mixed, hyperthermic Typic Rhodustalfs Coarse loamy, mixed, hyperthermic Typic Ustorthents	15	0.40
Miscellaneous		32	0.86
Total		3706	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (72D/7,8,11,12,14-16,72H/3,4,6,7,8,73A/9,13,14 and 73E/1,2) and all the maps were demarcated with grid points at 2.5 km interval.

Surface soil samples from demarcated grid points and other related informations were collected through field survey. Soil samples were air dried, processed and analysed for pH, organic carbon, available phosphorous and potassium (Page *et al.*, 1982), available nitrogen (Subbaiah and Asija, 1956), available sulphur by using 0.15 percent $CaCl_2$ as the extractant (William and Steinbergs, 1959), available (DTPA extractable) Fe, Mn, Zn and Cu (Lindsay and Norvell, 1978) and available B (hot water soluble) by Carmine method (Hatcher and Wilcox, 1950).

The soils are grouped under different soil reaction classess viz extreamely acidic (pH<4.5), very strongly acidic (pH 4.5 – 5.0), strongly acidic (pH 5.1 – 5.5), moderately acidic (pH 5.6-6.0), slightly acidic (pH 6.1-6.5), neutral (pH 6.6-7.3), slightly alkaline (pH 7.4-7.8), moderately alkaline (pH 7.9-8.4), strongly alkaline (pH 8.5-9.0) according to Soil Survey Manual (IARI, 1970).The soils are rated as low (below 0.50 %), medium (0.50-0.75 %) and high (above 0.75 %) in case of organic carbon, low (<280 kg ha^{-1}), medium (280 to 560 kg ha^{-1}) and high (>560 kg ha^{-1}) in case of available nitrogen, low (< 10 kg ha^{-1}), medium (10 to 25 kg ha^{-1}) and high (> 25 kg ha^{-1}) for available phosphorus, low (< 108 kg ha^{-1}), medium (108 to 280 kg ha^{-1}) and high (> 280 kg ha^{-1}) for available potassium and low (<10 mg kg^{-1}), medium (10-20 mg kg^{-1}) and high (> 20 mg kg^{-1}) for available sulphur (Singh *et. al.* 2004, Mehta *et. al.*1988). Critical limits of Fe, Mn, Zn, Cu and B, which separate deficient from non-deficient soils followed in India are 4.5, 2.0, 0.5, 0.2 and 0.5 mg kg^{-1} respectively. (Follet and Lindsay, 1970 and Berger and Truog, 1940).

The maps for the above mentioned parameters have been prepared using Geographic Information System (GIS) from data generated by analysis of grid soil samples.

4. SOIL ACIDITY AND FERTILITY STATUS

4.1 Soil Reaction

Soil pH is an important soil property, which affects the availability of several plant nutrients. It is a measure of acidity and alkalinity and reflects the status of base saturation. The soils of the district have been grouped under seven soil reaction classes according to Soil Survey Manual (IARI, 1970).

The soil pH ranges from 4.7 to 8.1. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that majority of the area is acidic (66.2 % of TGA), in which 27.4 percent area is moderately acidic, 19.0 percent slightly acidic, 15.8 percent strongly acidic and 4.0 percent very strongly acidic in reaction. Soils of 17.6 percent area of the district are neutral whereas 15.3 percent area is alkaline in reaction.

Table 2. Soils under different reaction classes

Soil reaction	Area (‘00ha)	% of the TGA
Very strongly acidic (pH 4.5 to 5.0)	147	4.0
Strongly acidic (pH 5.1 to 5.5)	584	15.8
Moderately acidic (pH 5.6 to 6.0)	1016	27.4
Slightly acidic (pH 6.1 to 6.5)	704	19.0
Neutral (pH 6.6 to 7.3)	654	17.6
Slightly alkaline (pH 7.4 to 7.8)	375	10.1
Moderately alkaline (pH 7.9 to 8.4)	194	5.2
Miscellaneous	32	0.9
Total	3706	100.0

4.2 Organic Carbon

The effect of soil organic matter on soil properties is well recognized. Soil organic matter plays a vital role in supplying plant nutrients, cation exchange capacity, improving soil aggregation and hence water retention and soil biological activity.

The organic carbon content in the district ranges from 0.10 to 1.74 %. They are mapped into three classes i.e., low (below 0.5 %), medium (0.5-0.75 %) and high (above 0.75 %) (Table 3 and Figure 3). From table 3 it is seen that 26.2 percent area of the district shows low organic carbon content. Medium and high organic carbon content constitute 35.8 and 37.1 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00ha)	% of the TGA
Low (below 0.50 %)	971	26.2
Medium (0.50-0.75 %)	1326	35.8
High (above 0.75 %)	1377	37.1
Miscellaneous	32	0.9
Total	3706	100.0

4.3 Macronutrients

Nutrients like nitrogen (N), phosphorus (P) and potassium (K) are considered as primary nutrients and sulphur (S) as secondary nutrient. These nutrients help in proper growth, development and yield differentiation of plants and are generally required by plants in large quantity.

4.3.1 Available Nitrogen

Nitrogen is an integral component of many compounds including chlorophyll and enzyme essential for plant growth. It is an essential constituent for amino acids which is building blocks for plant tissue, cell nuclei and protoplasm. It encourage aboveground vegetative growth and deep green colour to leaves. Deficiency of nitrogen decreases rate and extent of protein synthesis and result into stunted growth and develop chlorosis.

Available nitrogen content in the surface soils of the district ranges between 183 and 693 kg/ha and details are given in table 4 and figure 4. Majority soils (63.1 % of TGA) of the district have medium status of available nitrogen (280-560 kg ha^{-1}) and soils of 20.7 percent area have low available nitrogen content (<280 kg ha^{-1}).

Table 4. Available nitrogen status in the surface soils

Available nitrogen (kg ha^{-1})	Area ('00ha)	% of the TGA
Low (below 280)	768	20.7
Medium (280-560)	2340	63.1
High (above 560)	566	15.3
Miscellaneous	32	0.9
Total	3706	100.0

4.3.2 Available Phosphorus

Phosphorus is important component of adenosine di-phosphate (ADP) and adenosine tri-phosphate (ATP), which involves in energy transformation in plant. It is essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance in plant and animal. Phosphorous take part in important functions like photosynthesis, nitrogen fixation, crop maturation, root development, strengthening straw in cereal crops etc. The availability of phosphorous is restricted under acidic and alkaline soil reaction mainly due to P-fixation. In acidic condition it get fixed with aluminum and iron and in alkaline condition with calcium.

Available phosphorus content in these soils ranges between 1.0 and 29.3 kg/ha and their distribution is given in table 5 and figure 5. Data reveals that majority of the soils are low (78.3 % of TGA) followed by medium (20.5 % of TGA) and high (0.3 % of TGA) content of available phosphorous.

Table 5. Available phosphorous status in the surface soils

Available phosphorous class (kg ha^{-1})	Area ('00ha)	% of the TGA
Low (below 10)	2902	78.3
Medium (10-25)	760	20.5
High (above 25)	12	0.3
Miscellaneous	32	0.9
Total	3706	100.0

4.3.3 Available Potassium

Potassium is an activator of various enzymes responsible for plant processes like energy metabolism, starch synthesis, nitrate reduction and sugar degradation. It is extremely mobile in plant and help to regulate opening and closing of stomata in the leaves and uptake of water by root cells. It is important in grain formation and tuber development and encourages crop resistance for certain fungal and bacterial diseases.

Available potassium content in these soils ranges between 67 and 862 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that most of the soils (49.6 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 42.2 percent area are high (above 280 kg ha^{-1}) and 7.3 percent area are low (below 108) in available potassium content.

Table 6. Available potassium status in the surface soils

Available potassium (kg ha^{-1})	Area ('00ha)	% of the TGA
Low (below 108)	271	7.3
Medium (108-280)	1839	49.6
High (above 280)	1564	42.2
Miscellaneous	32	0.9
Total	3706	100.0

4.3.4 Available Sulphur

Sulphur is essential in synthesis of sulphur containing amino acids (cystine, cysteine and methionine), chlorophyll and metabolites including co-enzyme A, biotin, thiamine, or vitamin B1 and glutathione. It activates many proteolytic enzymes, increase root growth and nodule formation and stimulate seed formation.

The available sulphur content in the soils ranges from 0.36 to 47.38 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 28.1 percent of the area are low (<10 mg kg^{-1}) whereas soils of 38.3 and 32.7 percent area are medium (10-20 mg kg^{-1}) and high (>20 mg kg^{-1}) in available sulphur content respectively.

Table 7. Available sulphur status in the surface soils

Available sulphur (mg kg^{-1})	Area ('00ha)	% of the TGA
Low (<10)	1042	28.1
Medium (10-20)	1419	38.3
High (>20)	1213	32.7
Miscellaneous	32	0.9
Total	3706	100.0

4.4 Micronutrients

Proper understanding of micronutrients availability in soils and extent of their deficiencies is the pre-requisite for efficient management of micronutrient fertilizer to sustain crop productivity. Therefore, it is essential to know the micronutrients status of soil before introducing any type of land use.

4.4.1 Available Iron

Iron is constituent of cytochromes, haems and nonhaem enzymes. It is capable of acting as electron carrier in many enzyme systems that bring about oxidation-reduction reactions in plants. It promotes starch formation and seed maturation.

The available iron content in the surface soils ranges between 9.6 and 83.2 mg kg^{-1}. As per the critical limit of available iron (> 4.5 mg kg^{-1}), all the soils are sufficient in available iron. They are grouped and mapped into four classes. Majority of the soils (52.3 % of TGA) have available iron content between the range of 25 to 50 mg kg^{-1}. The details of area and distribution is presented in table 8 and figure 8.

Table 8. Available iron status in the surface soils

Available iron (mg kg^{-1})	Area ('00ha)	% of the TGA	Rating
<15	308	8.3	Sufficient
15-25	913	24.6	
25-50	1939	52.3	
50-100	514	13.9	
Miscellaneous	32	0.9	
Total	3706	100.0	

4.4.2 Available Manganese

Manganese is essential in photosynthesis and nitrogen transformations in plants. It activates decarboxylase, dehydrogenase, and oxidase enzymes.

The available manganese content in surface soils ranges between 7.6 and 64.7 mg kg^{-1}. As per the critical limit of available manganese (> 2 mg kg^{-1}), all the soils are sufficient in available manganese. They are grouped and mapped into four classes. Soils of 76.1 % area of district have available Mn content between 25 and 50 mg kg^{-1}. The details of area and distribution are presented in table 9 and figure 9.

Table 9. Available manganese status in the surface soils

Available manganese ($mg\ kg^{-1}$)	Area ('00ha)	% of the TGA	Rating
<10	40	1.1	Sufficient
10-25	503	13.6	
25-50	2822	76.1	
50-100	309	8.3	
Miscellaneous	32	0.9	
Total	3706	100.0	

4.4.3 Available Zinc

Zinc plays role in protein synthesis, reproductive process of certain plants and in the formation starch and some growth hormones. It promotes seed maturation and production.

The available zinc in surface soils ranges between 0.42 and 4.48 $mg\ kg^{-1}$. They are grouped and mapped into five classes. Soils of majority area (91.9 % of TGA) are sufficient (>0.5 $mg\ kg^{-1}$) whereas soils of 7.2 percent area are deficient (<0.5 $mg\ kg^{-1}$) in available zinc. The details of area and distribution are presented in table 10 and figure 10.

Table 10. Available zinc status in the surface soils

Available zinc ($mg\ kg^{-1}$)	Area ('00ha)	% of the TGA	Rating
<0.5	267	7.2	Deficient
0.5-1.0	942	25.4	Sufficient
1.0-2.0	2001	54.0	
2.0-3.0	381	10.3	
3.0-5.0	83	2.2	
Miscellaneous	32	0.9	
Total	3706	100.0	

4.4.4 Available Copper

Copper involves in photosynthesis, respiration, protein and carbohydrate metabolism and in the use of iron. It stimulates lignifications of all the plant cell wall and is capable of acting as electron carrier in many enzyme systems that bring about oxidation-reduction reactions in plants.

The available copper status in surface soils ranges between 0.18 and 4.38 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (97.6 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 1.5 % area are deficient in available copper (<0.2 mg kg^{-1}). The details of area and distribution are presented in table 11 and figure 11.

Table 11. Available copper status in the surface soils

Available copper (mg kg^{-1})	Area ('00ha)	% of the TGA	Rating
<0.2	57	1.5	Deficient
0.2-0.5	152	4.1	Sufficient
0.5-1.0	607	16.4	
1.0-2.0	1138	30.7	
2.0-4.0	1611	43.5	
4.0-6.0	109	2.9	
Miscellaneous	32	0.9	
Total	3706	100.0	

4.4.5 Available Boron

Boron increases solubility and mobility of calcium in the plant and it act as regulator of K/Ca ratio in the plant. It is required for development of new meristematic tissue and also necessary for proper pollination, fruit and seed setting and translocation of sugar, starch and phosphorous etc. It has role in synthesis of amino acid and protein and regulates carbohydrate metabolism.

The available boron content in the soils ranges from 0.07 to 4.48 $mgkg^{-1}$ and details about area and distribution is given in table 12 and figure 12. The critical limit for deficiency of the available boron is <0.5. Soils of 35.4 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 63.7 percent area are sufficient (>0.50 $mgkg^{-1}$) in available boron content.

Table 12. Available boron status in the surface soils

Available boron ($mg\ kg^{-1}$)	Area ('00ha)	% of the TGA	Rating
<0.25	420	11.3	Deficient
0.25-0.50	892	24.1	
0.50-0.75	1178	31.8	Sufficient
>0.75	1184	31.9	
Miscellaneous	32	0.9	
Total	3706	100.0	

5. SUMMARY

The soil pH ranges from 4.7 to 8.1. Most of the soils are acidic in reaction (66.2 % of TGA). Neutral soils cover 17.6 % area of the district and alkaline soil cover 15.3 percent area of the district. Organic carbon content in these soils ranges from 0.10 to 1.74 percent. Soils of 26.2 percent area of the district shows low organic carbon content whereas medium and high organic carbon content constitute 35.8 and 37.1 percent area respectively.

Available nitrogen content is medium (280-560 kg ha^{-1}) in majority soils (63.1 % of TGA) of the district and soils of 20.7 percent area have low available nitrogen content (<280 kg ha^{-1}). Majority of the soils (78.3 % of TGA) are low (below 10 kg/ha) in available phosphorous content followed by medium (20.5 % of TGA) and high (0.3 % of TGA).Most of the soils (49.6 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 42.2 percent area are high (above 280 kg ha^{-1}) and 7.3 percent area are low (below 108) in available potassium content. Available sulphur content ranges between 0.36 to 47.38 mg kg^{-1} and soils of 28.1 percent of the area is low (<10 mg kg^{-1}) whereas soils of 38.3 and 32.7 percent area are medium and high in available sulphur content respectively.

Soils are analyses for available (DTPA extractable) micronutrients and seen that all the soils are sufficient in available iron and manganese whereas soils of 7.2 and 1.5 percent area are deficient in available zinc and copper respectively. Available boron content in the soils ranges between 0.07 to 4.48 mg kg^{-1} and 35.4 percent area of district is deficient (<0.50 mg kg^{-1}).

REFERENCES

Berger, K. C. and Truog, E.(1940) J. Am. Soc. Agron. 32,297

Census of India (2001) Primary Census Abstract.

FAI (2003 – 2004) Fertiliser and agriculture statistics, Eastern Region.

Follet, R. H. and Lindsay , W. L.(1970) Tech. Bull. Colo. Agric. Exp. Station 110.

Haldar, A. K., Srivastava, R., Thampi, C. J., Sarkar, D., Singh, D. S., Sehgal, J and Velayutham, M. (1996) Soils of Bihar for optimizing land use. **NBSS Publ. 50b**. (Soils of India Series), National Bureau of Soil Survey and Land Use Planning, Nagpur, India, pp. 70+4 sheets soil Map (1:500,000 scale).

Hatcher, J. T. and Wilcox, L. V. (1950) Analyt. Chem. **22**, 567

I.A.R.I. (1970). Soil survey manual, All India Soil and Land Use Organization, Indian Agricultural Research Institute, New Delhi.

Lindsay , W. L. & Norvell, W.A.(1978). Development of a DTPA micronutrients soil test for Zn, Fe, Mn and Cu. *Soil Sci. Soc. Am. Proceedings*: 42, 421-428

Mehta, V. S. , Singh, V and Singh, R. P. (1988) J. Indian Society of Soil Science, 36, 743

Mishra, R. K. (2004) Planning for Food and Nutritional Security in Jharkhand, *Published by* Agricultural Data Bank, BAU, Ranchi, Jharkhand, p. 275

Page, A. L., Miller, R. H. and Keeney, D. R.(1982) Method of Soil Analysis, Part-II, Chemical and Microbiological Properties, Soil Sci. Soc. Am. And Am. Soc. Agron. Madison, Wisconsin, USA.

Singh Dhyan, Chhonkar, P. K. and Pandey, R. N.(2004) Soil Plant and Water Analysis, A Manual, IARI, New Delhi.

Subbaiah, B.V. and Asija, G.L. (1956). A rapid procedure for determination of available nitrogen in soil. Current Science 25, 259-260

Tandon, H. L. S. (Ed) (1999) Methods *of analysis of soils, plants, waters and fertilizers*. Fertilizer Development and Consultation Organisation, New Delhi, India.

William, C. H. and Stainbergs, A. (1959) Aust. J. Agric. Res. **10,** 342