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

SAHIBGANJ 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 was 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 Sahibganj district, Jharkhand.

2. GENERAL DESCRIPTION OF THE AREA

2.1 Location and Extent

Sahibganj district is located in the north east of the state. It is bounded by Bhagalpur and Godda district in the west, Maldah and Murshidabad district of West Bengal in the east, Ganga river and Katihar district in the north. It has an area of 1600 sq. km. area and population of 7,27,584 persons (Census of India, 2001). The district comprises two subdivisions (Sahibganj and Rajmahal) and nine development blocks viz. Taljhari, Rajmahal, Barharwa, Pathna, Barhait, Mandro, Udhwa, Sahibgunj and Borio.

2.2 Physiography, Geology and Drainage

The eastern portion of the district and narrow strip along the Ganga to the north consist of alluvial and *Diara* land. Whole of the western portion which is about 70 percent area consist of hills, valley and undulating land. To the north continuous hill extend parallel to Ganga and leaving narrow strip of level land between them and river. Geologically the area has basaltic trap and sedimentary beds. Quartz and gneisses are found in some places. Major drain lines are Gumani and Udhava *nala*.

2.3 Climate

The nearness to West Bengal and varied elevations influence the climatic condition. The district receives an annual rainfall of 1500 mm. and most of the rainfall occurs during the rainy season. During winter it becomes cool and record average temperature of 15^0C. but during summer temperature ranges from 30 to 40^0C.

2.4 Agriculture and Land Use

Plain areas have become almost devoid of vegetation but hilly area have considerable vegetative cover. Important trees are sal, mahua, jamun, semal, sisam, kathal etc. Important crops grown in plain are rice, wheat, maize and jute. During recent year people have started growing vegetable and seasonal fruits.

Land Use in Sahibganj District (1997-98)

		Sahibganj	Jharkhand
1.	Forest	21.18 %	29.2 %
2.	Net sown area	22.85 %	22.7 %
3.	Barren and unculturable waste	7.77 %	7.2 %
4.	Non agricultural use	8.04 %	9.9 %
5.	Orchards	1.46 %	2.5 % (Orchards and Pasture combined)
6.	Pasture	1.39 %	
7.	Culturable wasteland	3.25 %	3.5 %
8.	Current and other fallow	34.06 %	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 four soil orders namely Entisols, Inceptisols, Alfisols and Vertisols were observed in Sahibganj district (Fig.1 and table 1). Alfisols were the dominant soils covering 41.3 percent of TGA followed by Inceptisols (36.7 %), Entisols (10.5 %) and Vertisols (3.6 %).

Table 1. Soils of the district and their extent

Map unit	Taxonomy	Area ('00ha)	% of TGA
1	Coarse loamy, mixed, hyperthermic Typic Endoaquents Fine loamy, mixed, hyperthermic Typic Ustifluvents	7	0.44
2	Fine silty, mixed, hyperthermic Typic Haplustepts Fine silty, mixed, hyperthermic Typic Ustifluvents	65	4.06
3	Coarse loamy, mixed, hyperthermic Typic Ustifluvents Coarse loamy, mixed, hyperthermic Aquic Ustifluvents	136	8.50
5	Fine, mixed, hyperthermic Aeric Endoaquepts Fine silty, mixed, hyperthermic Typic Haplustepts	53	3.31
11	Fine, mixed, hyperthermic Aeric Endoaqualfs Fine, mixed, hyperthermic Typic Haplustalfs	94	5.87
13	Fine, mixed, hyperthermic Typic Endoaqualfs Fine, mixed, hyperthermic Typic Haplustalfs	212	13.25
14	Fine, mixed, hyperthermic Aeric Endoaquepts Fine, mixed, hyperthermic Vertic Endoaqualfs	36	2.25
88	Fine, mixed, hyperthermic Typic Haplustalfs Fine loamy, mixed, hyperthermic Typic Haplustepts	400	25.00
89	Loamy-skeletal, mixed, hyperthermic Lithic Rhodustalfs	54	3.37
90	Fine, mixed, hyperthermic Typic Haplustalfs Fine, mixed, hyperthermic Aeric Endoaquepts	18	1.13
92	Fine loamy, mixed, hyperthermic Typic Paleustalfs Fine loamy, mixed, hyperthermic Typic Haplustepts	59	3.69
93	Fine, mixed, hyperthermic Vertic Haplustepts Clayey-skeletal, mixed, hyperthermic Typic Haplustepts	195	12.19
94	Fine, mixed, hyperthermic Vertic Haplustepts Fine, mixed, hyperthermic Udic Haplusterts	144	9.00
Miscellaneous		127	7.94
Total		1600	100.00

3. METHODOLOGY

The base map of the district was prepared on 1:50,000 scale using Survey of India toposheets (72O/7,8,11,12,15,16 and 72P/5,9,13,10,14) 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 four soil reaction classes according to Soil Survey Manual (IARI, 1970).

The soil pH ranges from 4.9 to 8.1. The soil reaction classes with area are given in table 2 and figure 2. The data reveals that most of the soils (62.9 % of TGA) are acidic in reaction of which soils of 23.7 percent area are moderately acidic, 17.3 percent slightly acidic, 14.7 percent strongly acidic and 7.3 percent very strongly acidic in reaction. Neutral soil covers 14.6 percent area whereas slightly alkaline and moderately alkaline soils cover 4.7 and 7.9 percent area respectively.

Table 2. Soils under different reaction classes

Soil reaction	Area ('00 ha)	% of the TGA
Very strongly acidic (pH 4.5 to 5.0)	116	7.3
Strongly acidic (pH 5.1 to 5.5)	234	14.6
Moderately acidic (pH 5.6 to 6.0)	379	23.7
Slightly acidic (pH 6.1 to 6.5)	277	17.3
Neutral (pH 6.6-7.3)	234	14.6
Slightly alkaline (pH 7.4-7.8)	158	9.9
Moderately alkaline (pH 7.9-8.4)	75	4.7
Miscellaneous	127	7.9
Total	1600	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 0.12 to 2.84 %. They are mapped into three classes i.e., low (below 0.5 %), medium (0.5-0.75 %) and high (above 0.75 %). The details are given in table 3 and figure 3. From table 3 it is seen that 64.7 percent area have high surface organic carbon content. Medium and low organic carbon content constitute 15.8 and 11.6 percent area respectively.

Table 3. Organic carbon status

Organic carbon (%)	Area ('00 ha)	% of the TGA
Low (below 0.50 %)	185	11.6
Medium (0.50-0.75 %)	253	15.8
High (above 0.75 %)	1035	64.7
Miscellaneous	127	7.9
Total	1600	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 Sahibganj district ranges between 96 and 829 kg/ha and details are given in table 4 and figure 4. Majority area (66.1 % of TGA) of the district have medium availability status of available nitrogen (280-560 kg ha^{-1}) and 8.5 percent area have low available nitrogen content (<280 kg ha^{-1}).

Table 4. Available nitrogen status in the surface soils

Available nitrogen (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 280)	136	8.5
Medium (280-560)	1057	66.1
High (above 560)	280	17.5
Miscellaneous	127	7.9
Total	1600	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 1.2 and 19.8 kg/ha and area and distribution is given in table 5 and figure 5. Data reveals that soils of the 70.9 % area have low (below 10 kg ha^{-1}) in available phosphorous content, whereas 21.2 percent area have medium (10-25 kg ha^{-1}) available phosphorous content respectively.

Table 5. Available phosphorous status in the surface soils

Available phosphorous (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 10)	1134	70.9
Medium (10-25)	339	21.2
Miscellaneous	127	7.9
Total	1600	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 59 and 1008 kg/ha and details about area and distribution is given in table 6 and figure 6. The data reveals that most of soils (41.2 % of TGA) have medium available potassium content (108-280 kg ha^{-1}). Soils of 26.6 percent area are low (below 108) and 24.3 percent area are high (above 280 kg ha^{-1}) in available potassium content.

Table 6. Available potassium status in the surface soils

Available potassium (kg/ha)	Area ('00 ha)	% of the TGA
Low (below 108)	426	26.6
Medium (108-280)	659	41.2
High (above 280)	388	24.3
Miscellaneous	127	7.9
Total	1600	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 1.77 to 39.59 mg kg^{-1} and details about area and distribution is given in table 7 and figure 7. Soils of 56.3 percent of the area are low (<10 mg kg^{-1}) whereas soils of 19.5 and 16.3 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)	901	56.3
Medium (10-20)	312	19.5
High (>20)	260	16.3
Miscellaneous	127	7.9
Total	1600	100

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 is ranges between 9.1 and 74.8 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. Most of the soils (45.1 % 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	45	2.8	Sufficient
15-25	106	6.7	
25-50	722	45.1	
50-100	600	37.5	
Miscellaneous	127	7.9	
Total	1600	100	

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 9.5 and 51.0 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 73.8 % 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	6	0.4	Sufficient
10-25	110	6.9	
25-50	1181	73.8	
50-100	176	11.0	
Miscellaneous	127	7.9	
Total	1600	100	

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 4.44 mg kg^{-1}. They are grouped and mapped into five classes. Soils of majority area (89.8 % of TGA) are sufficient (>0.5 mg kg^{-1}) whereas soils of 2.3 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	36	2.3	Deficient
0.5-1.0	69	4.3	Sufficient
1.0-2.0	622	38.9	
2.0-3.0	520	32.5	
3.0-5.0	226	14.1	
Miscellaneous	127	7.9	
Total	1600	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 0.12 and 9.36 mg kg^{-1}. They are grouped and mapped into six classes. Majority of soils (90.3 % of TGA) have sufficient amount of available copper (>0.2 mg kg^{-1}) and soils of 1.8 % 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	28	1.8	Deficient
0.2-0.5	33	2.1	Sufficient
0.5-1.0	90	5.6	
1.0-2.0	275	17.2	
2.0-4.0	719	44.9	
4.0-10.0	328	20.5	
Miscellaneous	127	7.9	
Total	1600	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 3.78 $mgkg^{-1}$ 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 38.5 percent area of district are deficient (<0.50 $mgkg^{-1}$) whereas 53.6 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	267	16.7	Deficient
0.25-0.50	348	21.8	
0.50-0.75	314	19.6	Sufficient
>0.75	544	34.0	
Miscellaneous	127	7.9	
Total	1600	100.0	

5. SUMMARY

The soil pH ranges from 4.9 to 8.1. Most of the soils (62.9 % of TGA) are acidic in reaction. Neutral soil covers 14.6 percent area whereas slightly alkaline and moderately alkaline soils cover 4.7 and 7.9 percent area respectively. The organic carbon content in the district ranges from 0.12 to 2.84 %. Soils of 64.7 percent area have high surface organic carbon content. Medium and low organic carbon content constitute 15.8 and 11.6 percent area respectively.

Available nitrogen content in the surface soils of the Sahibganj district ranges between 96 and 829 kg/ha. Majority area (66.1 % of TGA) of the district have medium availability status of available nitrogen and 8.5 percent area have low available nitrogen content. Available phosphorus content in these soils ranges between 1.2 and 19.8 kg/ha. Soils of the 70.9 % area have low in available phosphorous content, whereas 21.2 percent area have medium available phosphorous content respectively. Available potassium content in these soils ranges between 59 and 1008 kg/ha. Most of soils (41.2 % of TGA) have medium available potassium content. Soils of 26.6 percent area are low and 24.3 percent area are high in available potassium content. Available sulphur content in the soils ranges from 1.77 to 39.59 mg kg^{-1} and soils of 56.3 percent of the area are low (<10 mg kg^{-1}) in available sulphur content.

All the soils of district are sufficient in available iron and manganese whereas soils of 2.3 and 1.8 percent area are deficient in available zinc and copper respectively. Available boron content in the soils ranges between 0.07 to 3.78 mg kg^{-1} and 38.5 percent area of district are deficient (<0.50 mg kg^{-1}).

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