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Evaluation of Sulphur Status in Soil of Some Selected Blocks of Varanasi District of Eastern of Uttar Pradesh

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ABSTRACT

The study was conducted in Varanasi district with a view to assess the soil available sulphur status at different block level. Geographically the district Varanasi is situated at $25^0$18' of Northern latitude, 83^0 03' of Eastern longitude and at an altitude of 128.83 m above the mean sea level in the Indo-Gangatic plain of eastern Uttar Pradesh. Soil samples were collected covering three blocks from 30 villages based on based on the variability of land at a depth of 0-20 cm. surface soil samples (one from each village) were collected. A Geographical Positioning System device was used to identify the location of the sampling points.Collected Soil samples were analyzed for pH, electrical conductivity, organic matter, sulphur cation exchange capacity, calcium carbonatestexture classes, Particle density, bulk density.The available sulphur content in soils of some selected blocks of Varanasi district varied from 19.26 to 98.38 kg/ha with a mean value of 57.64 kg/ha. The lowest value of (19.26kg/ha) as well as the highest value of (98.38kg/ha) available sulphur was recorded in soils of study area.

Key Words: Sulphur status, Soil fertility, Soil fertility maps, Nutrient index Macronutrients.

INTRODUCTION

The tremendously growing population in the country is an acute problem that demands maximum possible output of food, fiber and fuel from each unit of cultivated land area per unit time. The soil fertility undergoes change due to cropping, manure and fertilizer applications. Modern crop production technology has considerably raised the out-put but has created problem of land degradation, pesticide residual in farm produce, atmospheric and water pollution. The application of fertilizer on the basis of soil test will not only considerably reduce the cost of inputs for fixed targeted yield but also help in the balanced fertilizer application that will lead to better soil health and sustainability of production.

Sulphur is the fourth most important nutrient after nitrogen, phosphorus and zinc for Indian agriculture (Sakal and Singh, 1997). Sulphur is best known for its role in the synthesis of proteins, oils, vitamins and flavoured compounds in plants. It resembles nitrogen in its many functions in the plant and phosphorus in the amount taken up by plants. High yields of good quality produce become possible only when crop have access to optimum amount of sulphur. It is a constituent of three amino acids *viz.,* Methionin (21% S), Cysteine (26% S) and Cystine (27% S), which are the building blocks of protein. About 90% of plant sulphur is present in these amino acids (Tandon and Messick, 2002). Sulphur is also involved in the formation of chlorophyll, glucosides and glucosinolates (mustard oils), activation of enzymes and sulphydryl (SH-) linkages that are the source of pungency in onion, oils, etc. (Mengel and Krikby, 1987). Sulphur is associated with the production of crops of superior nutritional and market quality. Intensification of agriculture with high yielding varieties and multiple cropping coupled with the use of high analysis sulphur free fertilizers along with the restricted or no use of organic manures have accrued in depletion of the soil sulphur reserve. Soils, which are deficient in sulphur, cannot on their own provide adequate sulphur to meet crop demand resulting in sulphur deficient crops and sub-optimal yields. The knowledge of sulphur status throughout root zone is essential for improving sulphur nutrition of crops.

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Several soil factors influence the availability of sulphur and hence the status of different forms of sulphur in soils varies widely with soil type (Trivedi *et al,* 2000). Plant available sulphate can be extracted by calcium chloride or calcium orthophosphate solution and 10-13 mg SO4-S kg-1 surface soil was found to be crucial for the optimum plant growth. Sub-soil fertility also needs due consideration to have better prediction of sulphur supply in growing plants (Singh, 2001). Continuous use of nitrogen fertilizer without supplemental sulphur on low sulphur soils can reduce flour quality (Flaete *et al,* 2005). Sulphur does not affect only nitrogen utilisation and grain quality, but it also play some important part in the formation of the baking quality (Ryant and Hřivna, 2004).

MATERIAL AND METHODS

Description of the Study Area

Geographically the district Varanasi is situated at 25^{0}18' of Northern latitude, 83^{0} 03' of Eastern longitude and at an altitude of 128.83 m above the mean sea level in the Indo-Gangatic plain of eastern Uttar Pradesh. The district Varanasi having alluvial soil lies in semi-arid region to sub humid belt of Northern India. It is often subjected to extreme of weather condition. The mean annual precipitation is 1100 mm. The area occasionally experiences winter cyclonic rain during December to February .In term of percentage of total rainfall, about 84 per cent is received from June to September, 0.7 per cent October to December, 6 per cent from January to February and 9.3 per cent from March to May as premonsoonic rain .The mean relative humidity of this area is about 68% with maximum 82 per cent and minimum 30 per cent during July to September and April to early June, respectively. The minimum and maximum average temperature of the area range from 4.4^{0} to 28.2^{0}C, respectively. The temperature begins to rise from February onward until the summer often exceeding 45^{0}C in the month of May and June. During these extremely hot months desiccating winds blow from west to east and dust storm frequently occurs.

Soil Sampling and Analysis

Agriculture is an important livelihood activity among the people of Varanasi district. Major Agro ecosystems in Varanasi district are paddy, wheat and vegetables etc. four block of Varanasi were selected from different agro ecological zones. 35 Surface soil samples (0-15 cm) were collected in in butter paper bag as per the standard procedure. Quartering technique was used for preparation of soil sample. The samples were dried in air and passed through 2 mm sieve and stored in cloth bag.

Methods of Analysis of Soil

Physical and chemical properties of initial soil samples were determined in the laboratory by the standard procedures. The pH of soils were measured in 1: 2.5 (Soil: Water) suspension with the help of glass electrode digital pH meter.The soil water suspension was prepared in 1:2.5 (soil: water) ratio. The electrical conductivity of the filtrate of suspension was determined by Electrical Conductivity meter. Organic matter of the soils was estimated by chromic acid wet digestion method given by Walkley and Black (1934).The bulk and particle density were determined using pycnometer bottle in laboratory in disturbed soil sample (Black, 1965), The W.H.C. of the soils was measured in laboratory using Keen-Rackzowski box (Black, 1965).Particle size distributions of soils were estimated by Hydrometer method as described by Bouyoucos (1927), and then mechanical composition and textural classes were determined by using USDA textural triangle.Cation Exchange Capacity (CEC) of the soil was measured by centrifuge method through leaching the soil with a sodium acetate solution (pH 8.2) for replacement of exchangeable cations by Na^{+} ions. The excess of salts was washed down by alcohol and the adsorbed Na^{+} ions were replaced by NH_4^{+} ions using neutral N NH_4OAC solution. The Na^{+} ions, so released, from the exchange spots were measured flamephotometric ally, and serve as the measure of total exchange capacity of the soil (Hesse, 1971)

Methods of Analysis of Sulphur

Ten gram of air-dry soil was taken in 150 ml conical flask and 50 ml of 0.15% $CaCl_2$ solution was added. Content was shaken for 30 minute on a rotary shaker and filtered through Whatman No. 42 filter paper. Ten ml of this clean filtrate was taken in a 25 ml volumetric flask, added 1 ml of 0.25 % gum acacia solution, and made up the volume with distilled water and shaken thoroughly manually. One gm of $BaCl_2$ crystal was added to each flask and swirled to dissolve the crystals within 5-30 minutes of development of turbidity (white colour), the absorbance at 440 nm through spectrophotometer was recorded and estimated the available S status.

RESULTS AND DISCUSSION

Physical Properties of Soils

Bulk density

Bulk density of the collected soil samples of Varanasi district ranges from 1.20 to 1.34 Mg m^{-3} and Bulk density of loam and sandy loam soils varies from 1.20 to 1.36 Mg m^{-3} and those of sandy clay loam soils from 1.25 to 1.38 Mg m^{-3}; The bulk density in the soils of the study areas was found within 1.4 Mg m^{-3}. Thus, the soils of the study areas are fine-texture with higher porosities (Table 1).

Particle density

Particle density of cultivated soils of different villages of Varanasi district varied from 2.27-2.65 Mg m^{-3}. The mean value of particle density of districts are mostly the same (i.e. 2.5 Mg m^{-3}). Soil containing high amounts of organic matter will have particle densities around 2.40 Mg m^{-3}, as one cubic centimeter weights less than an equal volume of mineral soils.

Porosity

Porosity refers to the volume fraction of pores and an index of the relative pore volume in the soil. Its values usually vary from 0.30 to 0.60, i.e. 30 to 60%. Porosity of the collected soil samples of Varanasi district range from 43.80 to 50.81%. The variation in porosity of the soil generally occurs due to variation of organic matter and clay content. The porosity of the soil of Varanasi district was recorded 47.96 %.

Water Holding Capacity (WHC)

In India, millions of hectares of land produce very low yield of crops due to unfavourable soil physical conditions. The major soil physical constraints identified are low water retention and high permeability, slow permeability, surface and subsurface mechanical impedance and shallow depth of soils, which either restrict crop growth or reduce efficiency of basic inputs, such as water, fertilizer etc. The calculated mean value of WHC of cultivated soils of Varanasi district was noticed 47.01%. The WHC varied from 43.45-49.85%.

Particle distribution and textural classes of soils

In Varanasi district 70 per cent soils texture (USDA) are sandy loam, 20 per cent soils are sandy clay loam and 10 per cent soils are loam in texture. Thus, all the soils are loam texture which are most suitable for cultivation. The range of sand, silt and clay content varied from 50.28-71.88 per cent, 10.40-34.0 per cent and 10.72-24.72 per cent, respectively. Sand is mostly composed of quartz and micas. Silts are commonly composed of a mixture of quartz and small mineral particles, *viz.*, feldspars and micas. Clays are made up of secondary clay minerals.

Chemical Properties

The data on chemical properties of the soils in Varanasi district have been presented in Table 2

Soil pH

Data presented in table 2 show that the pH value ranges from 6.6-8.7 with mean value of 8.08. The pH of the study area of the cultivated lands of Varanasi district are mostly (66%) strongly alkaline (pH 8.1-9.0) in reaction and 28% are mildly alkaline (pH 7.4-8.0); rest only 6% soils are neutral (pH 6.6-7.3) in reaction due to different physiography of the locations.

Electrical Conductivity (E.C.)

Conductivity, as the measure of current carrying capacity, gives a clear idea of the soluble salts present in the soil. It plays a major role in the salinity of soils. Lesser the EC value, low will be the salinity value of soil and vice versa. This is a result of the shape and physical properties of the particles which make up the soil Data (Table 2) show that the electrical conductivity of some cultivated soils in Varanasi district varied from 0.144 to 0.320 with mean value of 0.220 dSm^{-1}. The category of the soils with respect to conductivity (total soluble salts) in normal, as the EC of soils are below 1.0 d Sm^{-1}

Soil Organic Matter

The term 'Soil organic matter' embraces the whole non-mineral fraction of soil, and consists essentially of a series of products, which range from decayed plant and animal tissues of fairly amorphous brown to black mineral, bearing no trace of the anatomical structure of the material, that is normally defined as the 'soil humus'. Because of the complex nature of soil humus which contains a wide variety of organic molecules, difficulties are encountered in the identification of such molecules.. Data (Table 2) show that the mean of SOM in the study area of was 7.81 g kg^{-1}.seventy three per cent of the cultivated lands was found in medium range of organic matter.

Calcium carbonate ($CaCO_3$) content

Carbonates in soil are mostly of calcium (calcite, $CaCO_3$) with occasional occurrence of dolomite [$CaMg\ (CO_3)_2$]. Carbonates may be derived from the parent rock or may be formed in soil by interaction of calcium released during weathering with the carbon dioxide of biological origin. Calcium carbonate is commonly absent in soils having pH less than 7.0.The calcium carbonate may present in pulverized form or as concretions of varying sizes. The pH of such soil is in the range 8.0-8.5. Calcium carbonate content in cultivated soils of Varanasi district varied from 0.25 to 5.0 %.

Cation exchange capacity (CEC)

Cation exchange capacity is defined the sum total of the exchangeable cations (major cations: Ca^{2+}, Mg^{2+}, K^+ and Na^+; minor: NH_4^+ other minors: Mn^{2+}, Zn^{2+}, Cu^{2+}, Fe^{2+} etc.; variable amount of H^+) that a soil can adsorb. The cation exchange capacity of the soil is depended on soil texture (CEC of the sand and silt fractions is neglected in the approximation of cation exchange since it is too small), nature of clay minerals, organic matter, soil reaction (CEC increases with increasing pH), nature of cations and their power of replacement. The CEC in the cultivated soils of Varanasi district varied 11.12 to 65.34 c mol (P^+) kg^1.

Available sulphur

The available sulphur content in soils of some selected blocks of Varanasi district varied from 19.26 to 98.38 kg/ha with a mean value of 57.64 kg/ha. The lowest value of (19.26 kg/ha) as well as the highest value of (98.38 kg/ha) available sulphur was recorded in soils of study area.

Nutrient Index

The soil samples were categorized into low, medium and high categories based on the critical limit of available sulphur (Hariram and Dwivedi, 1994) The nutrient index values (NIV) for available sulphur were calculated utilizing the formula suggested by Ramamoorthy and Bajaj (1969) as follow19.26-98.32 with mean value 57.64 kg/ha

$$\textbf{Nutrient Index} = \frac{(N_l * 1) + (N_m * 2) + (N_h * 3)}{N_T}$$

Where, N_l, N_m N_h and NT are the number of soil samples falling in low, medium high categories for nutrient status and is total number of samples analyzed for a given area are given weightage of 1, 2 and 3, respectively. The classified this nutrient index values are rated in various categories *viz.*, very low (<1.33), low (1.33 - 1.66), marginal (1.66 - 2.00), adequate (2.00 - 2.33), high (2.33 - 2.66)

Table.1 Physical properties of soils of study area.

S. No.	Location	Mgm^{-3}		Percentage					Textural Class
		B.D.	P. D.	Porosity	WHC	Sand	Silt	Clay	
1	Pura Raghunathpur	1.27	2.54	50.00	46.21	63.48	25.80	10.72	Sandy clay loam
2	Pura Raghunathpur	1.25	2.48	49.60	47.94	58.72	18.56	22.72	sandy loam
3	Pura Raghunathpur	1.21	2.27	46.70	48.25	50.78	34.00	15.22	loam
4	Raghunathpur	1.26	2.51	49.80	49.58	62.84	12.44	24.72	Sandy clay loam
5	Raghunathpur	1.30	2.46	47.15	45.26	67.88	17.40	14.72	Sandy loam
6	Raghunathpur	1.20	2.35	48.94	49.85	50.28	30.00	19.72	loam
7	Sagunaha	1.22	2.46	50.41	45.61	57.72	29.56	12.72	Sandy loam
8	Sehmalpur	1.20	2.39	49.79	47.22	69.74	16.54	13.72	Sandy loam
9	Sehmalpur	1.36	2.42	43.80	43.45	62.60	20.68	16.72	Sandy loam
10	Sehmalpur	1.37	2.45	44.08	44.71	64.72	16.52	18.76	Sandy loam
11	Sehmalpur	1.36	2.42	43.80	47.30	61.48	21.80	16.72	Sandy loam
12	Bhatauli	1.38	2.63	46.30	43.49	56.72	18.56	24.72	Sandy clay loam
13	Awashanpur	1.35	2.53	46.64	46.19	62.28	24.00	13.72	Sandy loam
14	Awashanpur	1.33	2.53	47.43	48.53	54.28	25.00	20.72	Sandy clay loam
15	Ghamahapur	1.30	2.61	50.19	46.90	56.27	28.56	15.17	sandy loam
16	Dharmalpur	1.32	2.45	44.90	49.05	58.28	28.00	13.72	Sandy loam
17	Dharmalpur	1.25	2.46	49.19	47.58	58.72	20.56	20.72	Sandy clay loam
18	Dharmalpur	1.20	2.39	49.79	46.67	58.88	22.40	18.72	Sandy loam
19	Sahapur	1.22	2.45	50.20	46.58	61.56	20.72	17.72	Sandy loam
20	Sahapur	1.36	2.60	47.69	48.52	62.40	21.88	15.72	Sandy loam
21	Sahapur	1.34	2.46	45.53	47.39	71.88	10.40	17.72	Sandy loam
22	Deura	1.35	2.57	47.47	48.25	62.28	18.00	19.72	Sandy loam
23	Deura	1.33	2.65	49.81	48.55	52.28	36.00	11.72	Sandy loam
24	Kashipur	1.36	2.53	46.25	43.69	50.72	28.56	20.72	Loam
25	Kashipur	1.21	2.46	50.81	48.33	62.72	19.56	17.72	Sandy loam
26	Kashipur	1.31	2.52	48.02	47.35	60.72	21.56	17.72	Sandy loam
27	Gaura	1.32	2.54	48.03	48.50	52.72	31.36	15.92	Sandy loam
28	Gaura	1.28	2.49	48.59	47.99	52.72	24.56	22.72	Sandy clay loam
29	Kashipur	1.32	2.61	49.43	44.47	60.72	24.56	14.72	Sandy loam
30	Gaura	1.28	2.48	48.39	46.78	60.28	23.00	16.72	Sandy loam
Range		1.20 -1.38	2.27-2.65	43.80-50.81	43.45-49.85	50.28-71.8	10.40-34	10.72-24.72	
Mean		1.29	2.49	47.96	47.01	59.56	32.02	17.43	
±S.D.		0.06	0.09	2.08	1.76	5.48	5.99	3.63	
C.V.		4.60	3.40	4.30	3.70	9.20	18.7	20.8	

±S.D. = Standard Deviation; C.V. = Coefficient of Variation, P.D.=Particle Density, B.D. = Bulk Density,WHC=Water Holding Capacity

Table. 2 Chemical properties of soil of study area.

S.No.	pH	EC dSm^{-1}	O M $g\ kg^{-1}$	$CaCO_3$ %	CEC Cmol (P^+) kg^{-1}	Available S $kg\ ha^{-1}$	Fertility Status of Sulphur		
							Low <22.4	Medium 22.4-44.8	High >44.8
1	8.5	0.275	12.39	4.50	18.42	72.13	-	-	High
2	8.0	0.361	12.69	3.75	48.30	83.55	-	-	High
3	8.2	0.161	15.45	0.50	25.50	27.31	-	Medium	-
4	8.2	0.163	12.69	2.25	65.34	45.39	-	-	High
5	7.7	0.138	11.42	3.25	43.62	82.91	-	-	High
6	8.1	0.182	14.69	3.00	44.42	75.72	-	-	High
7	8.1	0.871	13.77	1.25	18.33	39.29		Medium	-
8	8.5	0.185	14.78	1.50	45.27	69.56	-	-	High
9	8.0	0.132	4.70	0.25	15.12	60.35	-	-	High
10	8.2	0.148	7.720	2.25	15.55	51.93	-	-	High
11	8.6	0.158	8.400	0.50	19.03	47.84	-	-	High
12	8.1	0.182	5.66	2.75	16.33	61.14	-	-	High
13	8.6	0.165	8.400	2.50	13.64	19.26	Low		-
14	8.0	0.188	9.410	1.00	46.49	20.94	Low	-	-
15	8.1	0.195	11.08	5.00	12.16	79.26		-	High
16	8.7	0.262	11.08	0.50	18.24	21.09	Low		-
17	8.1	0.171	13.43	3.00	15.72	28.48	-	Medium	-
18	8.3	0.199	15.39	1.75	18.68	74.39	-	-	High
19	8.7	0.301	12.76	3.50	41.97	89.51	-	-	High
20	8.7	0.167	7.500	3.75	15.64	36.01	-	Medium	-
21	8.9	0.236	8.740	1.00	41.45	32.66	-	medium	-
22	6.6	0.198	9.70	0.25	11.20	75.18	-	-	High
23	6.0	0.172	9.07	2.75	15.72	78.66	-	-	High
24	8.2	0.171	8.07	1.50	22.85	62.90	-	-	High
25	7.5	0.157	13.77	0.00	15.64	73.63	-	-	High
26	7.5	0.144	11.75	4.50	15.03	54.45	-	-	High
27	7.6	0.224	22.49	4.20	23.02	76.70	-	-	High
28	8.4	0.214	13.43	1.50	16.42	98.32	-	-	High
29	7.3	0.159	5.04	3.25	18.16	56.43	-	-	High
30	7.7	0.320	12.76	4.50	11.12	34.21	-	Medium	-
Range	6.6-8.7	0.144-0.320	4.70-22.49	0.25-5.0	11.12-65.34	19.26-98.32	EC:Electrical Conductivity		
Mean	8.08	0.22	11.24	2.32	26.28	57.64	OM: Organic Matter		
S.D. ±	0.56	0.14	3.75	1.52	17.13	22.76	CEC:Cation Exchange Capacity		
C.V.	6.90	63.64	33.37	65.51	65.19	39.5			

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and very high (> 2.66) as suggested by Stalin *et al.* (2010).

CONCLUSION

Sulphur is present mostly in organic matter in soil. In tropics and subtropics, inorganic sulphur is present in sulphate form. Critical limit of $CaCl_2$ (0.15%) extractable sulphur in soils is about 10 mg/kg i.e. 22.4 kg/ha. Only 10 per cent soils were found below the critical limit of plant available sulphur in study area. Plant available sulphur content in Varanasi district ranged 19.26-98.32 with meanvalue 57.64 kg/ha and nutrient index value<2.60.The overall nutrient index values were high for available Sulphur.

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