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EVOLUTION OF AVAILABLE SULPHUR STATUS AND THEIR RELATIONSHIP WITH SOME PHYSICO-CHEMICAL PROPERTIES OF SOIL OF SELECTED BLOCKS OF BASTAR DISTRICT, CHHATTISGARH

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ABSTRACT

A study on the evolution of available sulphur status and their relationship with some physico-chemical Properties of soil of selected blocks of Bastar district, Chhattisgarh and reported that available sulphur (S) varied from 13.72 to 92.96 (mean 38.31 kg ha^{-1}) found 14.28 % samples under (L), 38.09 % in (M) and 47.61 % in (H) status of S and **OC** level ranged from 0.19-0.96 (mean 0.65 %) at Jagdalpur block and 10.08 to 95.76 (40.14 kg ha^{-1}) falls under L, M and H categories as 21.21, 18.66 and 62.12 %, respectively and OC varied from 0.17-0.97 (mean 0.67 %). In Bakawand block, S varied from 11.20 to 75.52 (29.98 kg ha^{-1}) and the % samples tested under L, M and H status S were found as 33.33, 22.91 and 43.75 %, respectively and OC ranged from 0.17-0.96 (mean 0.66 %). It was also found that the overall 23.07 % samples under low, 24.36 % medium and 52.56 % in high status of S and Jagdalpur, Bakawand block was indicated positive correlation with soil pH and positive with OC status. Similarly Bastar block was recorded negative correlation with Soil pH and positive with OC. The overall nutrient index values for S status of Bastar district were found medium (2.29) fertility class.

INTRODUCTION

In India, nearly 57 MH of arable lands suffer from various degree of sulphur deficiency (Tripathi, 2003). Now a day's fast depletion of natural resource of sulphur is becoming widespread due to use of high yielding crop varieties (HYVs), intensive multiple cropping system ,high S requiring crops and continuous use of S free fertilizers as well as restricted use of organic manure coupled with its leaching from root zone are largely responsible for increasing S deficiency in *Inceptisol* soil (Sammi Reddy *et al.*, 2001 and Singh *et al.*,2010).

Sulphur is one of the essential nutrients required for the plant growth.It is not only an often growth-limiting plant nutrient but also indirectly affects the use efficiency of other plant nutrients, such as N (De Bona and Monteiro, 2010). It is now assuming importance next to major nutrient *i.e.*, nitrogen, phosphorus and zinc for Indian agriculture. Sulphur is an essential macronutrient in plant growth and development. It is increasingly being recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium (Parakhia *et al.,* 2016). Role of sulphur in the synthesis of fatty acids and also increases protein quality in different crop through the synthesis of certain amino acids such as cystene, cysteine and methionine (Choudhary *et al.,* 2014). The availability of S is largely dependent on its fraction. About 90% of plant sulphur is present in these amino acids. Sulphur deficiencies in India are found in almost 40% of the cultivated area. Several soil factors influence the availability of sulphur and hence the status of different forms of S in soils varies widely with soil type. Again high annual rainfall (>2000mm) in Assam enhances leaching of SO_4, leaving these soil deficient in S (Borkotoki and Das 2008).Form of S and their interrelationship with soil properties, on other hand; determine the sulphur supplying power of the soil through their influence on release and dynamics of S in soil (Sammi Reddy *et al.*,2001). Geographic Information System Arc (GIS) 9.3 based soil fertility mapping has appeared as a promising alternative. Limiting sulphur availability has been shown to favour the synthesis and accumulation of S-poor or low-S storage proteins at the expense of S-rich proteins. (Flaete *et al.*, 2005). It has been widely used for determination of available soil S. However, the amount of S extracted by this method is affected by the extraction time and temperature and the potential resorption of S during the cooling period (Goswami *et al.*,2014). The present research work was taken as efforts to evaluate the S status of Bastar district of Chhattisgarh with the help of GIS and GPS techniques and their interrelationships with some phisico-chemical properties of soil.

MATERIALS AND METHODS

Bastar lies between 19º 11' 60N latitude and 81º 55' 60E longitude. The total geographical area is 14974 km^2 .The climate of the district is Dry Sub-humid with annual rainfall of 1541 mm. One hundred fifty six surface soil samples were collected from three selected blocks of Bastar district *viz*. Jagdalpur (42), Bastar (66) and Bakawand (48) in which total 26 villages were selected based on stratified multistage random sampling method covering all the blocks and a total of 156 surface soil samples (six from each village) were collected using GPS and represented small, medium and large resources framers' category. The selected samples were analyzed for soil pH (1:2.5) soil: water suspension after stirring for 30 minutes by glass electrode pH meter as suggested by Piper (1967), Organic Carbon as referred by Walkley and Black's rapid titration method (1934) and the most suitable and widely used method for estimation of available sulphur was done as suggested by (Williams and Steinberg's 1969) using 0.15% $CaCl_{2.}H_2O$ as an extractant and measured using turbid metrically. These samples were analyzed for available sulphur status to categories them into low, medium and high and correlated with pH and organic carbon level. Standard statistical procedure for correlation study was followed. The categorization of the soils of the individual blocks as a whole in to the three fertility classes was done according to the nutrient index values calculated from the soil test summarized giving their percentage distribution into low, medium and high categories. The nutrient index (Muhr *et al*. (1965) was given by-

Nutrient index = [% samples in high category × 3 + % in medium Category × 2 + % in low category × 1] / 100

In this percent assessment, a nutrient index less than 1.65 denotes low category and that falling between 1.65 and 2.33 represents the medium fertility class. Value of 2.34 and above (maxi 3.00) signifies a high fertility class in respect of the particular nutrient (Ghosh and Hasan, 1976).

Actual soil sampling using multistage stratified random sampling was carried out in the selected blocks. The topo sheet containing selected blocks were digitized and geo-referenced with known features. Thus, digitized map might used for preparation of soil fertility map using Kriging technique to interpolate the information. Here, Global positioning system (GPS) was used to identify actual locations (latitude longitude data of collection *etc*.) of sample points.

Kriging is an advanced geo-statistical procedure that generates an estimated surface from a scattered set of points with Z-values. The first step in ordinary kriging is to construct a variogram from the scatter point set to be interpolated. The method of kriging is based on the regionalized variable theory that assumes that the spatial variation in the phenomenon represented by the Z- values is statistically homogenous throughout the surface *i. e*., the same pattern of variation can be observed at all locations on the surface. This hypothesis of spatial homogeneity is fundamental to the regionalized variable theory. The spatial variation can be quantified by the semi-vario gram. The semi vario gram was estimated by the sample semi-vario gram which was computed from the input point data. The vaules of the sample semi-vario gram for separation distance of H (referenced to as the Lag) is the average squared distance in Z value between pairs of input sample points separated by H. The sample semi vario gram can be calculated from the sample data with the following equation (Singh *et al*.,2010)

$$Y(h) = 1/2\sum_{i=1}^{n}\{Z(Xi) - Z(Xi) - Z(Xi) - Z(Xi+h)\}^2$$

Where n is the number of pairs of sample points separated by distance h and Z (xi)'s are the value of the characteristic under study at i^{th} location (i = 1, 2, 3,..., n).

RESULTS

Fourty two soil samples out of one hundred fifty six were collected from Jagdalpur block using GPS and presented in (Table-1). Available S ranged from 13.72 to 92.96 (mean 38.31 kg ha^{-1}) in Table-6, OC % ranged from 0.19-0.96 (mean 0.65%) and pH ranged from 5.70-7.92 (mean 6.83) presented in Table-3and4.Considering the soil test rating for available sulphur (<20 as low, 20-30 as medium, >30 kg ha^{-1} as high status), the distribution of S status of Jagdalpur block under different soil S rating can be classified as in the range from 13.72-19.88 with mean value of 16.10 kg ha^{-1}, 20.16-27.44 with mean value of 23.71 kg ha^{-1} and 30.24-92.96 with mean value of 56.64 kg ha^{-1} under Low, Medium and High soil S rating, respectively (Table-7).The per cent samples distribution under soil test rating can be stated that majority of soil sample of Jagdalpur block contained 47.61 % high S level, 38.09 %

Table 1: Locations of soils collected for analyse the available sulphur

S.N.	Blocks	No. of sampled villages	Total No. of soil samples
1.	Jagdalpur	7	42
2.	Bastar	11	66
3.	Bakawand	8	48
	Overall	26	156

Table 2: Distribution and categorization of organic carbon status.

S.N.	Blocks	Total No. of soil samples	No of Sample			% Sample		
			Low (<0.50)	Medium (0.50-0.75)	High (>0.75)	Low	Medium	High
1.	Jagdalpur	42	12	15	15	28.57	35.71	35.71
2.	Bastar	66	15	24	27	22.72	36.36	40.90
3.	Bakawand	48	11	18	19	22.91	37.5	39.58
	Total	156	38	57	61	24.35	36.53	39.10

Table 3: Block wise range and mean values on soil pH

S.N.	Blocks	No. of sample	pH Rang	Mean	S.D
1.	Jagdalpur	42	5.70-7.92	6.83	±0.65
2.	Bastar	66	4.80-8.04	6.59	±0.64
3.	Bakawand	48	6.16-7.67	6.56	±0.39
	Total	156	5.70-8.04	6.54	±0.56

Table 4: Block wise range and mean values on soil OC

S.N.	Blocks	No of Sample	No of Sampled Villages	OC % Rang	Mean	S.D
1.	Jagdalpur	42	7	0.19-0.96	0.65	±0.22
2.	Bastar	66	11	0.17-0.97	0.67	±0.20
3.	Bakawand	48	8	0.17-0.96	0.66	±0.20
	Total	156	26	0.17-0.97	0.66	±0.20

Table 5: Category of soil samples under different pH rating of selected four blocks.

S.N.	Blocks	Total No . of soil samples	No of Sample Strongly acid (<5.5)	Mode rately acid (5.5-6.5)	Slightly acid (6.5-7.5)	Neutral (7.5-8.5)	Slightly alkaline (>8.5)	% Sample Strongly acid (<5.5)	Moderately acid (5.5-6.5)	Slightly acid (6.5-7.5)	Neutral (7.5-8.5)	Slightly alkaline (>8.5)
1	Jagdalpur	42	0	23	7	12	0	0	54.76	16.66	5.04	0
2	Bastar	66	3	34	20	9	0	1.98	51.51	13.2	13.63	0
3	Bakawand	48	0	35	10	3	0	0	72.91	20.83	6.25	0
	Total	156	3	92	37	24	0	1.92	58.97	23.71	15.38	0

Table6 : Distribution of Available Sulphur in the soils of selected blocks of Bastar.

S.N.	Blocks	No of sample	Available S (kg/ha) Min.	Max.	Mean.	Percent Samples Low (<20)	Medium (20-30)	High (>30)	S.D.
1.	Jagdalpur	42	13.72	92.96	38.31	6(14.28%)	16(38.09%)	20(47.61%)	± 23.80
2.	Bastar	66	10.08	95.76	40.14	14(21.21%)	11 (18.66%)	41 (62.12%)	± 22.29
3.	Bakawand	48	11.20	72.52	29.98	16(33.33%)	11 (22.91%)	21(43.75%)	± 15.33
	Overall	156	11.67	87.08	36.14	36(23.07%)	38(24.36%)	82(52.56%)	± 20.47

The figures in the parenthesis indicate the percent sample distribution

Table 7: Important properties and available Sulphur status in selected soil samples Of Jagdalpur block (Range and mean).

S.N.	Particulars	pH	OC %	Availabe (S) (Kg ha^{-1})
1	Soils low in available S	6.24-7.92 (6.67)	0.35-0.95 (0.7)	13.72-19.88 (16.1)
2	Soils medium in available S	6.27-7.68 (6.55)	0.19-0.96 (0.63)	20.16-27.44 (23.71)
3	Soils high in available S	5.70-7.80 (7.11)	0.25-0.96 (0.65)	30.24-92.96 (56.64)

The figures in the parenthesis indicate the mean value of the respective properties.

Table 8: Important properties and available Sulphur status in selected soil samples of Bastar block (Range and mean).

S.N.	Particulars	pH	OC%	Available (S)(Kg ha^{-1})
1.	Soils low in available S	6.24-7.60(6.76)	0.35-0.95(0.69)	10.08-19.60(16.20)
2.	Soils medium in available S	6.10-6.74(7.4)	0.33-0.94(0.66)	20.16-29.68(24.49)
3.	Soils high in available S	4.80-8.04(6.57)	0.22-0.97(0.67)	30.24-95.76(52.52)

The figures in the parenthesis indicate the mean value of the respective properties

Table 9: Important properties and available Sulphur status in selected soil samples Of Bakawand block (Range and mean).

S.N.	Particulars	pH	OC %	Available (S) (Kg ha^{-1})
1	Soils low in available S	6.24-6.66 (6.38)	0.30-0.90 (0.64)	11.20-19.88 (16.03)
2	Soils medium in available S	6.27-6.66 (6.45)	0.17-0.87 (0.59)	20.16-29.68 (23.83)
3	Soils high in available S	6.16-7.67 (6.71)	0.27-0.96 (0.71)	31.36-72.52 (43.84)

The figures in the parenthesis indicate the mean value of the respective properties.

Table 10: Correlation between soil characteristics and available sulphur (Kg ha^{-1})

S.N.	Blocks	pH	O.C (%)
1	Jagdalpur	0.495**	0.154
2	Bastar	-0.07	0.18
3	Bakawand	0.706**	0.065

*significant at 5% level ;** significant at 1% level

Table 11: Mean value of soil fertility index and soil fertility classes in soils of three selected blocks of Bastar districts

S.No.	Blocks	Mean value of fertility index	Soil fertility class
1.	Jagdalpur	1.95	Med
2.	Bastar	2.40	High
3.	Bakawand	2.10	Med
	Overall	2.29	Med

under medium level and 14.28 % falls under low S level (Table-6).similarly the per cent samples distribution under soil test rating can be stated that majority of soil sample of Jagdalpur block contained 35.71 % high OC level, 35.71% under medium level and 28.57 % falls under low OC level (Table-2). Table-5 shows that the soil pH ranges were neutral to moderately acidic. The calcium chloride extractable-S showed positive correlation with OC (r = 0.154) and significant positive correlation (r = 0.495**) with soil pH at 5% and 1% level of significant (Table-10) .These results confirmed the finding as reported by Isitekhal *et al.* (2013) in soils of Edo Central Nigeria, Kundu and Mukhopadhyay (2005) from Haringhata block of Nadia district (WB) and Mail and Syed (2002) in soil of 240 districts of the India including Maharashtra.

Similarly Sixtee six soil samples out of one hundred fifty six were collected from Bastar block using GPS and presented in (Table-1).Available S ranged from 10.08 to 95.76 (mean 40.14 kg ha^{-1}) in Table-6, OC % ranged from 0.17-0.97 (mean 0.67 %) and pH ranged from 4.80-8.04 (mean 6.59) presented in Table-3and4.the distribution of S status of Bastar block under different soil S rating can be classified as in the range from 10.08-19.60 with mean value of 16.20 kg ha^{-1}, 20.16-29.68 with mean value of 24.49 kg ha^{-1} and 30.24-95.76 with mean value of 52.52 kg ha^{-1} under Low, Medium and High soil S rating, respectively (Table-8).The percent samples distribution under soil test rating can be stated that majority of soil sample of Bastar block contained 62.12 % high S level, 18.66 % under medium level and 21.21% falls under low S level (Table-6).similarly the per cent samples distribution under soil test rating can be stated that majority of soil sample of Bastar block contained 40.90 % high OC level,36.36 % under medium level and 22.72 % falls under low OC level (Table-2).Table-5 show that the soil pH range were neutral to Moderately acidic. The calcium chloride extractable-S showed positive correlation with OC (r = 0.180) and negative (r = - 0.070) with soil pH (Table-10).These results confirmed the finding as reported by Isitekhal *et al.* (2013) in soils of Edo Central Nigeria, Singh *et al.,* 2009 in soils of Udham Singh Nagar district, Uttarakhand and Jat and Yadav (2006) in soil of Jaipur district Rajasthan.Forty eight soil samples out of one hundred fifty six were collected from Bakawand block using GPS and presented in (Table-1).Available S ranged from 11.20 to 75.52 (mean 29.98 kg ha^{-1}) in Table-6,OC % ranged from 0.17-0.96 (mean 0.66 %) and pH ranged from 6.16-7.67 (mean 6.56) presented in Table-3and4.Considering the soil test rating for available sulphur (<20 as low, 20-30 as medium, >30 kg ha^{-1} as high status), the distribution of S status of Bakawand block under different soil S rating can be classified as in the range from 11.20-19.88 with mean value of 16.03 kg ha^{-1}, 20.16-29.68 with mean value of 23.83 kg ha^{-1} and 31.36-72.52 with mean value of 43.84 kg ha^{-1} under Low, Medium and High soil S rating, respectively (Table-9).The per cent samples distribution under soil test rating can be stated that majority of soil sample of Bakawand block contained 43.75 % high S level, 22.91 % under medium level and 33.33 % falls under low S level (Table-6).similarly the per cent samples distribution under soil test rating can be stated that majority of soil sample of this block contained 39.58 % high OC level,37.50% under medium level and 22.91 % falls under low OC level (Table-2).Table-5 show that the soil pH range were found Moderately acid. The calcium chloride extractable-S showed positive correlation with OC (r = 0.065) and (r = 0.706) positive significant correlation with soil pH at 5% and 1% level of significant (Table-10).These results confirmed the finding as reported by Isitekhal *et al.*(2013) in soils of Edo Central Nigeria and Kundu and Mukhopadhyay (2005) from Haringhata block of Nadia district (WB), Ashoka *et al.* (2001) from different agro-climatic zones of Karnataka.

Nutrient index value

Using the model of Ramamurthy and Bajaj (1969) for nutrient index values to categorize the fertility class as low, medium and high, the analyzed data on soil S status were put under the different nutrient index values. Based on the nutrient index values Jagdalpur, Bastar and Bakawand blocks can be categorized under medium, high and medium fertility status of S (Table-11). The nutrient index value for S status of Jagdalpur, Bastar and Bakawand blocks were estimated as 1.95, 2.40 and 2.19 respectively against the nutrient index values <1.65 for low, 1.65-2.33 for medium and > 2.33 for high fertility status (Meena *et al.*).The overall nutrient index values for S status of Bastar district were found medium (2.29) fertility class.

DISCUSSION

There was a negative correlation of available S ($CaCl_2$ extractable $SO4^{-2}$-S) with soil pH and $CaCO_3$ contents in the soils. According to Biswas *et al.* (2003) $SO4^{-2}$ retention capacity of soils decreases with increasing soil pH and becomes almost negligible at pH values above 6.5 (Srinivasarao *et al.*, 2004). Thus under high soil pH conditions, $SO4^{-2}$ retention in soils is minimum which favors its leaching losses. In calcareous soils, $SO4^{-2}$ may react with $CaCO_3$ to get converted into insoluble forms unavailable to plants (Havlin *et al.,* 2004; Srinivasarao *et al.,* 2004). Soils in low Organic Carbon are possibly because of high temperature and good aeration in the soil which increased the rate of oxidation of organic matter (Singh and Mishra.2012).

REFERENCES

Ashoka, K. B. 2001. Sulphur status of selected soil series of Karnataka and studies on direct and residual effect of graded level of sulphur on crop. *M. Sc. (Agri.) Thesis*, University of Agricultural Sciences, Dharwad.

Biswas, H., Rattan,R. K., Datta,S. P and Singh,A. K. 2003. Adsorption and translocation of sulphur in some tropical acid soils. *J. Plant Nutrition and Soil Science*. **166:** 519-524.

Borkotoki, B. and Das, K. N.2008 Forms of sulphur and their relationship with soil properties in Entisols, Inceptisols, and Aalfisols of Assam. *J. the Indian Society of Soil Science*. **56**: 186-191.

Choudhary, P., Jhajharia, A. and Kumar, R. 2014. Influence of sulphur and zinc fertilization on yield, yield components and quality traits of soybean. *The Bioscan*. **9(1):** 137-142.

De Bona, F. D., Monteiro, F. A. 2010. Nitrogen and sulfur fertilization and dynamics in a Brazilian Entisol under pasture. *Soil Science Society of America J.***74:** 1248-1258.

Flaete, N. E. S., Hollung, K., Ruud, L., Sogn, T., Faergestad, E. M., Skarpeid, H. J., Magnus, E. M. and Uhlen, A. K. 2005. Combined nitrogen and sulphur fertilisation and its effect on wheat quality and protein composition measured by SE-FPLC and proteomics. *J. Cereal Science*. **41(3):** 357-369.

Ghosh, A. B. and Hasan, R. 1976. Available potassium status of Indian soil. *Indian Society of Soil Science*. **12:** 1-18.

Goswami, R. G., Mishra, V. N. and Srivastava, L. K. 2014. Evaluation of Sulphur Status in Soil of Bemetara District of Chhattisgarh Plain. *Research J. Agricultural Sciences*. **5(5):** 1000-1002.

Havlin, J. L., Beaton,J. D., Tisdale,S. L. and Nelson,W. L. 2004. *Soil fertility and fertilizers, an introduction to nutrient management*. Singapore: Pearson Education.

Isitekhale, H. H. E., Aboh, S. I. and Oseghale, E. S. 2013. Sulphur status of some soil in endo state, Nigeria. *International J .Scientific and Technology Research* Volume. **2(5):** 91-94.

Jackson, M. L. 1967. Soil Chemical Analysis. Published by Prentice Hall of India Pvt.Ltd. New Delhi.pp.263-393.

Jat, J. R. and Yadav, B. L. 2006. Different forms of sulphur and their relationship with properties of *Entisols* of Jaipur district (Rajasthan) under mustard cultivation. *J.Indian Soc. Soil Sci.* **54(2):** 208-212.

Kumar, R., Sarkar, A. S., Singh, K. P., Agarwal, B. K. and Karmakar, S. 2009. Appraisal of available nutrients status in Santhal Paraganas region of Jharkhand. *J. Indian Soc. Soil Sci*.**57(3):** 366-369.

Kundu,M. C.,Chakrabortty,S and Mukhopadhyay, P. 2005. Soil Fertility Status of Rice Growing Soil of Four Villages of Haringhata Block under Nadia District of West Bengal *Environment and Ecology*.**23(4):** 922-925.

Mali, C. V. and Syed, I. 2002. Characterization and fertility status of Marathwada soils sulphur and Micro-nutrients in soil resource inventory of Marathwada, *Department of Agricultural Chemistry and Soil Science, MAU, Parbhani*. pp.72-87.

Meena H. B., Sharma, R. P and Rawatn, U. S. 2006. Status of macro and micro nutrients in some soils of Tonk district of Rajasthan.*J.Indian Soc.Soil Sci*. **54:** 508-512.

Muhr, G. R., Datta, N. P., sankarasubramoney, H., Leley, V. K. and Donahue, R. L. 1965. Soil testing in India. 2nd Ed. USAID Mission to India, New Delhi.

Parakhia, D. V., Parmar, K. B., Vekaria, L. C., Bunsa, P. B. and Donga, S. J.2016. Effect of various sulphur levels on dry matter, yield and yield attributes of soybean. *The Ecoscan*. **10(1and2):** 51-54.

Piper, C. S. 1966. *Soil and Plant Analysis*. Hans Publisher, Bombay. pp. 85-102.

Ramamoorthy, B. and Bajaj, J. C. 1969. Available nitrogen, phosphorus and potassium status of Indian soils. *Fert. News* **14:** 25-28.

Sammi Reddy, K., Tripathi, A. K., Singh, M., Subba Rao, A. and Anand Swarup. 2001. Sulphate sorption-desorption characteristics in relation to properties of some acid soil .*J. the Indian Society of Soil Science*. **49:** 74-79.

Shankaraiah, M., Sreemannarayana, B. and Srinivasaraju, A.2006. Studies on the status and distribution of sulphur in black soils of Karimnagar district, Andhra Pradesh. *Indian J.Dryland Agric.Res. and Dev*. **21(1):** 74-79.

Singh, K. N., Rathore, A., Tripathi, A. K., Rao, A. S. and Khan, S.2010. Soil fertility mapping and its validation using spatial prediction technique. *J. Indian Society of Agricultural Statistics*. **64(3):** 359-365.

Singh, R. P. and Mishra, S. K. 2012. Available macronutrient in the soil of Chiraigaon block of district Varanasi (U.P.) in relation to soil characteristics. *Indian J.Sci.Res*.**3(1):** 97-100.

Singh, S. P., Singh, R., Shrivastava, P. C. and Singh, P. 2009. Different forms of sulphur in soils of Udham Singh Nagar district, Uttarakhand and their relationship with soil properties.*Agropedology* 2009. **19(l):** 68-74.

Srinivasarao, C., Ganeshamurthy,A. N., Ali, M. and Singh,K. K.2004. Sulphur availability and response of mung bean and urdbean to sulphur on different soil types of pulse growing regions of India. *Communications in Soil Science and Plant Analysis*. **35:** 1713-1723.

Tripathi, N. 2003. Role of FCO in promoting quality secondary and micronutrient Fertilizers News. **48:** 111-114.

Trivedi, S. K., Bansal K. N., Tomar, R. A. S and Verma, R. S. 2000. Vertical distribution of forms of sulphur in some profiles of Morena and Bhind district of Madhya Pradesh. *J. Indian Soc.Soil Sci*. **48:** 238-241.

Walkley, A. and Black, C. A. 1934. Estimation of soil organic carbon by chromic acid titration method. *Soil Sci*. **47:** 29-38.

Williams, C. H. and Steinberg's, A.1969. Soil Sulphur fraction as chemical indices of available sulphur in some Australian soil. *Aust. j. Agric. Res*. **10:** 340-352.