Reprint **ISSN 1994-1978 (Web Version)**

Journal of Soil and Nature (JSN)

(*J. Soil Nature*)

Volume: 7	Issue: 1	March 2014

J. Soil Nature 7(1): 13-18 (March 2014)

DISTRIBUTION OF SULPHUR IN ACID SOILS, LAKKATURA TEA GARDEN, SYLHET

M.R. ISLAM, H. AFROZ, M.M. PARVIN, F. YEASMIN AND M.M. HOQUE

An International Scientific Research Publisher

Green Global Foundation©

Web address: http://ggfjournals.com/e-journals archive
E-mails: editor@ggfjournals.com and editor.int.correspondence@ggfjournals.com

ISSN-1994-1978 (Online)
***J. Soil Nature* 7(1):13-18(March 2014)**

DISTRIBUTION OF SULPHUR IN ACID SOILS, LAKKATURA TEA GARDEN, SYLHET

M.R. ISLAM[1*], H. AFROZ[1], M.M. PARVIN[1], F. YEASMIN[2] AND M.M. HOQUE[3]

[1]Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh; [2]Department of Agricultural Extension & Rural Development, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh; [3]Department of Food Engineering and Tea Technology, Shahjalal University of Science and Technology, Sylhet, Bangladesh.

*Corresponding author & address: Dr. Md. Rafiqul Islam, E-mail: mrislam69@yahoo.com
Accepted for publication on 20 February 2014

ABSTRACT

Islam MR, Afroz H, Parvin MM, Yeasmin F, Hoque MM (2014) Distribution of sulphur in acid soils, Lakkatura tea garden, Sylhet. *J. Soil Nature* 7(1), 13-18.

A study was undertaken with soils collected from four locations of Lakkatura Tea Garden, Sylhet to evaluate the distribution of S and its relationship with soil properties. The soil samples were collected from two depths, 0-15 cm and 15-30 cm covering 0 year, 20 year, 40 year and 60 year tea cultivated soils. The soil samples were analyzed for various S fractions including total S, organic S, inorganic S and available S. The available S in soils was extracted with four different extractants *viz.* MCP (500 ppm P), NH_4OAc (0.5M), $CaCl_2$ (0.15%), NaH_2PO_4 (in 2N acetic acid). Different S fractions showed a variation in their levels and also showed a decrease in subsurface soils. The total S content varied in different aged tea soils ranging from 506.53 to 661.20 ppm at 0-15 cm depth but at 15-30 cm depth it varied from 404.07 to 624.60 ppm in different tea cultivated soil. The highest total S content of 661.2 ppm was found in 0 year age tea soil and the lowest value of 404.06 ppm was found in 60 year age tea cultivated soil. The highest organic S content of 127.41 ppm was found at 0-15 cm depth in 0 year tea cultivated soil and the lowest value of 67.28 ppm was found in 60 year tea cultivated soil. The inorganic S content of soils varied from 410.83 to 543.46 ppm at 0-15 cm depth and from 336.79 to 532.83 ppm at 15-30 cm. The organic and inorganic S constituted on an average 17.52% and 82.92% of total S, respectively. The available S content of soils varied considerably with the variation of soils and extractants used. The highest content of available S was observed in 0 year age tea cultivated soil with all the extractants while the 60 year age tea cultivated soil showed the lowest value. Among all the extractants MCP gave the highest available S while NaH_2PO_4 gave the lowest values. The mean value of S extracted by different extractants followed the order of MCP> NH_4OAc> $CaCl_2$> NaH_2PO_4.

***Key words**: sulphur distribution, acid soils, S extractants*

INTRODUCTION

Sulphur (S) is the fourth most important nutrient after NPK for agriculture (Sakal and Singh, 1997). S in soils is present in both organic and inorganic forms and the proportion of inorganic to organic S varies widely depending upon the nature of soil, its depth and management factors to which the soil is subjected. Distribution of different forms of S and their interrelationship with soil characteristics decides S availability in soil by influencing its release and dynamics in soils. Plants take up S in the form of Sulphate (SO_4^{2-}). A large proportion of soil S exists in the form of organic compounds which must be mineralized to sulphate S to be available to plants. Soil characteristics particularly texture, clay minerals, pH, and organic matter may influence the contents of plant available S by controlling the retention and leaching characteristics of highly mobile SO_4-S in soils (Haneklaus *et al*. 2002; Biswas *et al*. 2003).

Tea (*Camellia sinensis*) plays an important role in the economy of Bangladesh. Bangladesh ranks the 10th in the world for tea production. There is a wide scope to increase tea production if we can use full potential of tea soil for tea cultivation. However, tea has a particular need for S, over and above its function as a major nutrient for rapid healthy growth and development. S fertilizers are additionally used as soil amendment products to increase soil acidity in tea estate rehabilitation. S is important as a soil amendment chemical to generate and maintain a favored low pH for the acid-loving tea bush. The most important commercial function lies in its close association with specific tea chemicals that give the liquor sought after taste, color, brightness, strength and body. It seems strange that the quality of a fine aroma beverage like tea should depend heavily on an unpleasant smelling chemical like S (Mabbett 2005).

S deficiency in Bangladesh soils is becoming widespread and acute due to introduction of high yielding crop varieties, inadequate application of S fertilizers and intensive cropping systems coupled with higher productivity. Low organic matter and its rapid decomposition under high temperature of Bangladesh have further deteriorated S reserves in soils (Hoque 1986). At present, information regarding S status of tea soils and its relationship with soil physico-chemical properties is generally lacking. In view of above facts, the present study was undertaken to determine the distribution of different fractions of S and the relationship of these fractions with soil properties in different aged tea soils of Lakkatura tea Garden, Sylhet.

MATERIALS AND METHODS

The study was undertaken with some soils collected from the Lakkatura Tea Garden, Sylhet. The soils belong to the Agro-ecological Zone 20, Eastern Surma-Kushyara Floodplain. Soil samples were collected from four different age group of tea crop grown for 0 year, 20 year, 40 year and 60 year in Lakkatura Tea Garden, Sylhet. Twenty four composite soil samples were collected from the sampling sites at two different depths of 0-15 cm and 15-30 cm. The collected soil samples were carried to the laboratory, air dried at room temperature, mixed thoroughly, crushed, sieved with a 10-mesh sieve. Total sulphur content was estimated by acid digestion method as per procedure given by Tabatabai, 1982. For determining organic sulphur the soil sample was ignited with $NaHCO_3$ at 500ºC for 3 hours in an electric furnace and then S was extracted with NaH_2PO_4 solution in 2N acetic acid (Bradsley and Lancaster, 1960). Inorganic sulphur was calculated by subtracting organic sulphur from the total sulphur. Available S of the soil was extracted by four different extractants (Table 1). S in the extract was determined turbidimetrically using spectrophotometer (Jenway 6300). Particle size analysis of soil was done by hydrometer method (Bouyoucos 1927) and the textural class was determined by plotting of the values for %sand, %silt and %clay to the Marshall's Triangular Coordinate following the USDA system. Organic matter was determined by Walkley and Black method (Walkley and Black, 1934). The soils were also analyzed for pH (1:2.5 soil-water) by glass electrode pH meter method (Michael Peech 1965), total N by Semi-micro Kjeldahl method (Bremner and Mulvaney, 1982), available P by Olsen method (Olsen *et al.* 1954), exchangeable K by Flame Photometer after extraction with 1N NH_4OAc at pH 7.0 (Knudsen *et al.* 1982) and CEC (Chapman 1965). Simple correlation values were calculated to determine the relationship between sulphur fractions and soil parameters.

Table 1. Extractant used for determining available S in soils

Extractant	Soil extractant ratio	Shaking time (min.)	Reference
Monocalcium phosphate (500 ppm P)	1:5	30	Fox *et al*. (1964)
Calcium chloride (0.15%)	1:5	01	Williams and Steinbergs (1959)
Ammonium acetate (0.5 M)	1:2.5	05	Bardsley and Lancaster (1960)
Sodium dihydrogen phosphate (in 2N acetic acid)	1:5	30	Hoeft *et al.* (1973)

RESULTS AND DISCUSSION

Sulphur fractions in soil

Total sulphur

The data on the total sulphur fractions of soils were presented in Table 2. The total S content of soils ranged from 506.53 to 661.20 ppm at 0-15 cm depth but at 15-30 cm depth it varied from 404.07 to 624.60 ppm in different age of tea cultivation. The highest Total S content of 661.2 ppm was found at 0-15cm depth in 0 year tea cultivated soil and the lowest value of 404.06 ppm was found at in 60 year tea cultivated soil. In general, the total S values are higher 0-15cm depth than 15-30 depth of soils. This might be due to higher content of organic matter in surface soil than subsoil. The present study is in agreement with Patel and Patel (2008) who also reported that total S showed a decreasing trend with increase in profile depth.

Table 2. Total, organic and inorganic S status of different soils under study

Age	Depth (cm)	Total S (ppm)	Organic S(ppm)	Inorganic S (ppm)
0 Year	0-15	661.2±5.80	127.41±1.46	533.79±9.61
	15-30	624.87±15.80	100.79±1.73	512.33±12.41
20 Year	0-15	659.27±8.86	115.81±1.77	543.46±10.31
	15-30	620.60±15.80	87.77±2.68	532.83±14.69
40 Year	0-15	630.53±18.80	113.87±1.46	516.4±18.64
	15-30	491.07±12.80	85.45±2.70	405.62±12.61
60 Year	0-15	506.53±13.39	95.7±1.74	410.83±11.92
	15-30	404.07±20.37	67.28±10.06	336.79±14.74

Results are the means ± SD of three replicates

Organic sulphur

The data in Table 2 shows that organic sulphur content of soil ranges from 95.7 to 127.41 ppm with a mean of 113.19 ppm at 0-15 cm depth but at 15-30 cm depth the value varied from 67.28 to 112.13 ppm with a mean of 88.15 ppm which accounted for 18.90-19.26% and 16.65-17.95% of total S, respectively (Fig. 1). These results are found to be low compared to observations made by Islam *et al.* (1997) who pointed out organic S made up 20.4-38.2% and 24-31.2% of total S at 0-20 cm and 20-50 cm soil depth, respectively in some soil series of Bangladesh. The highest organic S content of 127.41 ppm was found at 0-15 cm depth in 0 year tea cultivated soil and the lowest value of 67.28 ppm was found in 60 year tea cultivated soil. In general, the status of organic S content decreased in lower depth of soils. The present study is well corroborated with Samaraweera (2009) who recorded a lower value of organic sulphur in subsurface layer than surface layer.

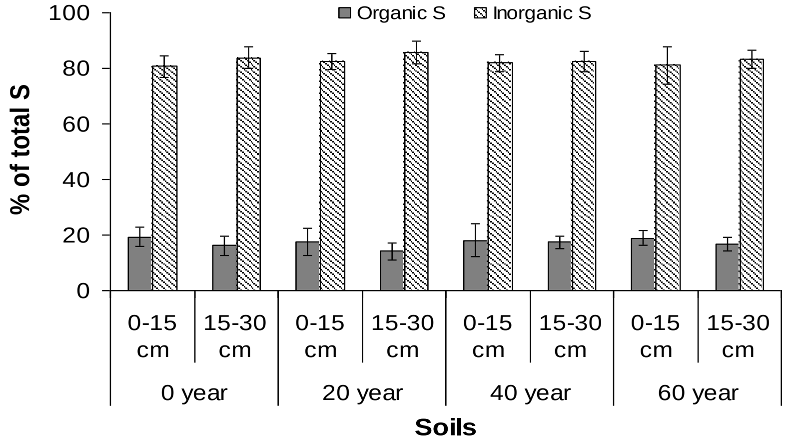

Fig. 1. Organic and inorganic S as a percentage of total S in different soils

Inorganic sulphur

Results in Table 2 indicate that the inorganic S content of soils ranged from 410.83 to 543.46 ppm with a mean of 506.12 ppm and 336.79 to 532.83 ppm with a mean of 446.90 ppm at 0-15 cm and 15-30 cm depth, respectively which accounted for 81.10-82.43% and 83.34-85.85 % of total S, respectively (Fig. 2). The highest inorganic S content of 543.46 ppm was found at 0-15 cm depth in 20 year tea cultivated soil and the lowest value of 336.79 ppm was found in 60 year tea cultivated soil. These results support the findings of Islam *et al.* (1997) who found 70% of total S as inorganic sulphur and the inorganic S decreased with increase in depth.

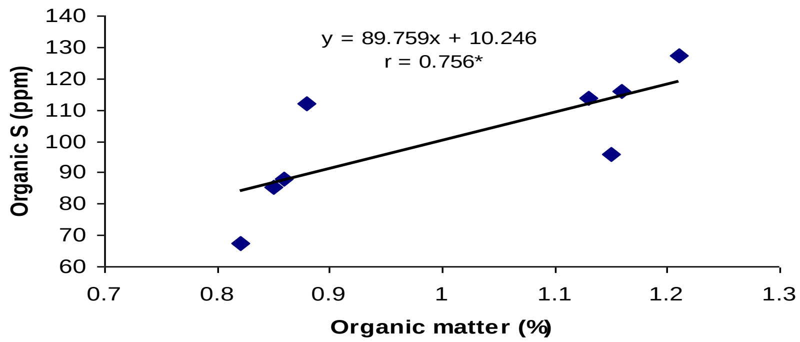

Fig. 2. Relationship between organic S and organic matter content of soils

Available S extracted with different extractants

MCP extractable S

Results in Table 3 indicate that the MCP-S ranged from 9.40 to 43.80 ppm at 0-15 cm depth and from 8.51 to 42.92 ppm at 25-30 cm depth in different aged tea soils. The highest content of MCP-S was found in 0 aged tea soils at 0-15 cm depth and the lowest of 8.51 ppm was observed at 15-30 cm depth in 60 year cultivated soil. Islam *et al*. (1997) observed that MCP extractable S ranged from 23.3-71.4 ppm at 0-20 cm depth in different soil series of Bangladesh. Huda (2000) observed that MCP extractable S varied from 3.0-26.0 ppm with a mean value of 11.5 ppm at 0-15 cm depth of Old Brahmaputra Floodplain soil (AEZ-9) in Mymensingh district.

NH_4OAc extractable S

Data in Table 3 revealed that the content of S extracted by (0.5M) NH_4OAc-S ranged from 12.61 to 26.08 ppm at 0-15 cm depth and from 7.52 to 16.91 ppm at 15-30 cm depth in different aged tea soils. The highest content of NH_4OAc-S 26.08 ppm was found in 0 aged tea soils at 0-15 cm depth and the lowest value of 7.52 ppm was observed at 15-30 cm depth in 60 year cultivated soil.

$CaCl_2$ extractable S

The amount of $CaCl_2$ extractable S varied markedly depending on the soils and extractant used. Data in Table 3 shows that $CaCl_2$ extractable S varied from 9.65 to 11.91 ppm at 0-15 cm depth and 8.64 to 9.55 ppm at 15-30 cm depth in different aged tea soils. The highest $CaCl_2$ extractable S of 11.91 ppm was found at 0-15 cm depth in 0 year tea cultivated soil and the lowest of 8.64 ppm was observed at 15-30 cm depth in 60 year cultivated soil. Huda (2000) observed that $CaCl_2$ extractable S varied from 3.0-86.1 ppm at 0-15 cm depth of Old Brahmaputra Floodplain soil (AEZ-9) in Mymensingh district.

Table 3. Available sulphur status of soils as determined by different extractants

Age	Depth (cm)	Available S (mg/Kg))			
		MCP	NH_4OAC	$CaCl_2$	NaH_2PO_4
0 Year	0-15	43.80±0.87	26.08±0.34	11.91±0.88	11.66 ±0.15
	15-30	42.92±0.77	16.91±0.23	9. 55±0.70	10.08±0.97
20 Year	0-15	25.23±0.87	23.80±0.50	10.27±0.64	9. 81±1.68
	15-30	23.59±1.02	14.39±0.92	8. 74±0.46	8.53±0.48
40 Year	0-15	21.36±0.44	13.57±0.29	10.06±0.81	9.35±0.73
	15-30	16.14±0.33	8.71±0.29	9.04±0.46	8.34±0.42
60 Year	0-15	9.40±1.13	12.61±0.34	9.65±0.35	7.89±0.42
	15-30	8.51±1.60	7.52±0.21	8.64±0.63	7.33±0.58

Results are the means ± SD of three replicates

NaH_2PO_4 extractable S

Results in Table 3 indicate that the NaH_2PO_4-S ranged from 7.89 to 11.66 ppm at 0-15 cm depth and from 7.33 to 10.08 ppm at 15-30 cm depth in different aged tea soils .The highest content of NaH_2PO_4-S 11.66 ppm was found in 0 year aged tea soils at 0-15 cm depth and the lowest value of 7.33 ppm was observed at 15-30 cm depth in 60 year cultivated soil.

Results in Table 3 indicate that the available S content of the soils varied considerably with the variation of soil and extractants used. The highest content of available S was observed in 0 aged tea cultivated soil at 0-15 cm depth with all the extractants. It was found that among all the extractants MCP gave the highest available S while NaH_2PO_4 gave the lowest values. The available S values extracted with $CaCl_2$ and NaH_2PO_4 were lower and more or less closer. The available sulphur extracted by different extractants followed the order of MCP> NH_4OAc> $CaCl_2$> NaH_2PO_4. These results are in agreement with the findings of Akter (2003) who showed the relative efficiency of the extractants as MCP> HCl> $NaHCO_3$> NH_4OAc> $CaCl_2$.

Relationship between S fractions and soil properties

Table 4 shows the linear relationship between S fractions and some soil properties. The results indicated that total S was non-significantly correlated with organic matter, total N and soil pH but significantly and positively correlated with EC (r = 0.722*), exchangeable K^+ (r = 0.867**) and Na^+ (r = 0.854*). Organic S was significantly and positively correlated with organic matter (r = 0.756*), (Fig. 2), total N (r = 0.823*), exchangeable Na (r = 0.938*) and K^+ (r = 0.979**) But non-significantly correlated with pH. The positive relationship of organic-S with organic matter suggested a Simultaneous increase in the status of organic-S in soil. Singh *et al*. (2007) observed that sulphur forms (i.e. total S and organic-S) gave significant positive correlations with total nitrogen. Inorganic S was significantly correlated with exchangeable Na (r = 0.799*) and K^+ (r = 0.805*). The MCP extractable S showed significant and positive correlation with soil pH (r = 0.930**), exchangeable Na^+ (r = 0.894**), EC (r = 0.840**) and exchangeable K^+ contents (r = 0.0.837**) but was negatively correlated with available P. Howlader (2004) observed that MCP extractable S negatively correlated with available P.

Table 4. Relationship of sulphur fractions with other soil properties

S fractions	Clay	pH	EC	% OM	Total N	Available P	K^+	Na^+	CEC
Total S	0.572	0.562	0.722*	0.534	0.655	0.349	0.867**	0.854**	0.677
Organic S	0.176	0.672	0.823*	0.756*	0.823*	0.505	0.979**	0.938**	0.539
Inorganic S	0.651	0.512	0.668	0.456	0.587	0.296	0.805*	0.799*	0.686
MCP	0.213	0.930**	0.840**	0.226	0.414	-0.123	0.837**	0.894**	0.346
NH_4OAC	0.292	0.718*	0.942**	0.683	0.839**	0.277	0.867**	0.873**	0.791*
$CaCl_2$	-0.110	0.646	0.808*	0.832*	0.890**	0.520	0.894**	0.884**	0.513
NaH_2PO_4	0.170	0.840**	0.888**	0.547	0.700	0.230	0.968**	0.985**	0.471

*Significant at the 0.05 level of probability
** Significant at the 0.01 level of probability

The $CaCl_2$ extracted S was positively and significantly correlated with total N (r = 0.890**), exchangeable K (r = 0.893**), Na (r = 0.883**), organic matter (r = 0.832*) and negatively correlated with clay (r = -0.111) (Table 4). Huda *et al*. (2000) observed that S availability in soils was positively correlated with organic matter and total N. Rashid *et al*. (2000) reported that S availability in soils was positively correlated with organic matter content. The NaH_2PO_4-extacted S was positively and significantly correlated with exchangeable Na^+ (r = 0.883**), K^+ (r = 0.968**), EC (r = 0.888**) and pH (r = 0.841**). The NH_4OAc extractable S was positively and significantly correlated with exchangeable EC (r = 0.890**), pH (r = 0.709*), exchangeable K^+ (r = 0.753*) and Na^+ (r = 0.777*).

CONCLUSION

The overall results indicate that the status of various S fractions varied from soil to soil and in some soils the level of available S recorded only a small portion of the total S (1.1%) indicating the existence of P deficiency. The inorganic S content of soils was low in comparison with organic S in different soils. The highest content of available S was observed in 0 year tea cultivated soil estimated with all the extractants. The 60 year round tea cultivated soil showed the lowest available S determined with all the extractants. Therefore, proper management practices with S fertilization are needed for tea cultivation in Lakkatura Tea Garden.

REFERENCES

Akter N (2003) Extractable sulphur in soils and its role on the growth of mustard. M.S. Thesis, Dept. of Agril. Chem., Bangladesh Agril. Univ, Mymensingh, Bangladesh, pp. 47-48.

Bardsley CE, Lancaster JD (1960) Determination of reserve sulphur and soluble sulphates in soils. Soil. Sci. Soc. Amer. Proc. 24, 265-268.

Biswas H, Rattan RK, Datta SP, Singh AK (2003) Adsorption and translocation of sulphur in some tropical acid soils. *J. Plant Nutri. Soil Sci*., 166, 519-524.

Black CA (1965) Methods of Soil Analysis part-1 and part-II. Amer. Soc. Agron. Inc. Madison, Wiscosin, USA. p. 770.

Bouyoucos GJ (1927) The hydrometer as a method for the mechanical analysis of soils. Soil Sci., 23, 343-353.

Bremner JM, Mulvaney CS (1982) Nitrogen-Total. In methods of soil Analysis Part 2. Edited by A.L. Page, R.H. Miller and D.R. Keeney. pp. 595-624. Amer. Soc. Agron. Inc. and Soil Sci. Soc. Amer. Inc., Madison, Wisconsin.

Chapman HD (1965) Cation exchange capacity. In Methods of Soil Analysis Part-2 edited by C.A. Black. Amer. Soc. Agron., Inc. Publisher, USA. pp. 891-901.

Fox RL, Olsen RA, Rhoades HF (1964) Evaluating the sulphur status of soils by plant and soil tests. Soil Sci. Soc. Amer. Proc. 28, 243-246.

Haneklaus S, Bloem E, Schnug E (2002) Sulphur. In Encyclopedia of Soil Science-Soil Fertility and Plant Nutrients. New York, USA: Marcel Dekker.

Hoeft RG, Walsh LM, Kunly IR (1973) Evaluation of various extractants for available soil sulphur. Soil Sci. Soc. Amer. Proc. 37, 401-404.

Hoque MS (1986) Sulphur status in some Bangladesh soils and response of rice to sulphur applications. In Sulphur in Agricultural Soils, S. Portch and S. G. Hossain ed. Bangladesh Agric. Res. Council, Dhaka.

Huda MN (2000) Determination of critical limit of sulphur for T.aman Rice. M.S. Thesis. Dept. of Soil Sci., BAU, Mymensingh, Bangladesh. pp. 56-57.

Islam MR, Hoque MS, Islam MR (1997) Distribution of different forms of sulphur in some selected soils of Bangladesh. Progress. Agric. 8(1&2), 129-132.

Knudsen D, Peterson GA, Pratt PF (1982) Lithium, Sodium and Potassium. In methods of Soil Analysis Prt 2 edited by Page, Miller and Keenly. Amer. Soc. Agron., Inc. Publisher, USA. pp. 225-245.

Mabbett T (2005) Sulphur brightness the brew. *Tea and Coffea Trade J*. 177(2), 124-127.

Michael Peech (1965) Hydrogen-ion activity. In methods of soil analysis part 2 edited by C. A. Black. Amer. Soc. Agron., Inc. Publisher, USA pp. 914-926.

Olsen SR, Cole CV, Watanable FS, Dean LA (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U. S., Dept. Agric. Circ. pp. 207-215.

Patel JC, Patel KC (2008) Profile distribution of different forms of sulphur in prominent soil series of South Gujarat. *Asian J. Soil Sci.* 3(1), 24-29.

Rashid A, Iqbal S, Naeem MA, Rafique E (2000) Nutrient indexing of sulphur in rainfed peanut growen in potahar plateau of pakistan. *J. Indian Soc. Soil Sci.*, 48(1), 124-129.

Sakal R, Singh AP (1997) Sulphur in Balanced Fertilisation in Eastern India. (in) Proc. The Suphur Institute (TSI)/Fertiliser Association of India (FAI) / International Fertiliser Industry Association (IFA) Symp. on Sulphur in Balanced Fertilisation, New Delhi, SI-2 /16.

Samaraweera DN (2009) Studies on forms and transformation of sulphur and response of rice to sulphur application in rice-rice cropping sequence. Ph.D. Thesis, Dept. of Soil Sci. and Agril. chem., Univ. Agric. Sci., Dharwad, Karnataka (India).

Singh AH, Singh RK, Singh LN, Singh G, Nandini C, Singh AK (2007) Sulphur status and forms in acid soils of Manipur. *Indian J. Agric. Res.*, 41(3), 205-209.

Tabatabai MA (1982) Sulphur, In Methods of Soil Analysis Ed. Page, A. L. et al. ASA, Madison, Wisconsin, USA.

Walkley, Black CV (1934) An examination of the Degtjereff method for determining soil organic matter and a proposed modification for the chromic acid titration method. Soil Sci. 37, 29-38.

Williams CH, Steinbergs A (1959) Soil sulphur fractions and chemical indices of available sulphur in some Australian soils. *Australian J. Agric. Res.*, 10, 340-352.